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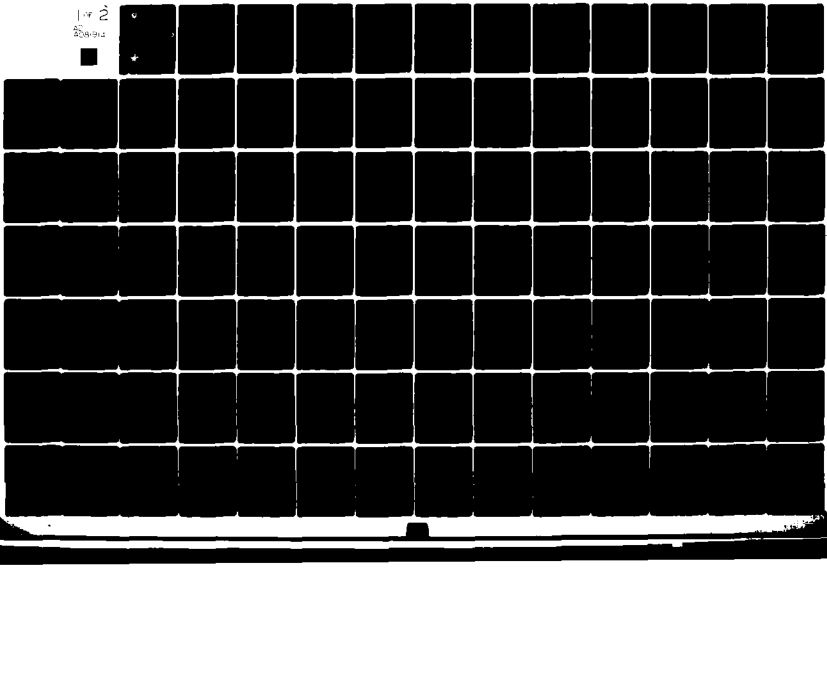

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UNITED STATES ARMY

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IMPACT OF INCREMENTAL CHANGES IN 7S FUNDING ON SUPPLY PERFORMANCE (DELTA 7S)

FINAL REPORT

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) IMPACT OF INCREMENTAL CHANGES IN 7S FUNDING ON SUPPLY PERFORMANCE; DELTA 7S	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William T. Craddock	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Logistics Management Center Systems and Cost Analysis Department (DRXMC-C-SCAD) Ft Lee, VA 23801	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Materiel Development and Readiness Command ATTN: DRCDRM-TG 5001 Eisenhower Avenue Alexandria, VA 22333	12. REPORT DATE August 1979
	13. NUMBER OF PAGES 156
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Goal Programming
Resource Allocation
Program 7S

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The DELTA 7S Study was an effort to develop an improved methodology to allocate budget changes within the US Army Materiel Development and Readiness Command (DARCOM) Central Supply System. The methodology developed serves as an alternative to the historical method of distributing fund changes on a pro rata basis. Regression analysis and input-output analysis provide linear equations which describe relationships between resources (dollars), workload, and performance. These equations are incorporated into a goal programming model, which then determines the optimal allocation according to the assigned priorities. The model is computerized and is accessed interactively by the user.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

IMPACT OF INCREMENTAL CHANGES IN 7S FUNDING ON SUPPLY PERFORMANCE (DELTA 7S)

by

William T. Craddock

August 1979

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Fort Lee, Virginia 23801

DISCLAIMER

Information and data contained in this report are based on input available at the time of preparation. Because the results may be subject to change, this report should not be construed to represent the official position of the US Army Materiel Development and Readiness Command unless so stated by that Command.

ABSTRACT

The DELTA 7S Study was an effort to develop an improved methodology to allocate budget changes within the US Army Materiel Development and Readiness Command (DARCOM) Central Supply System. The methodology developed serves as an alternative to the historical method of distributing fund changes on a pro rata basis. Regression analysis and input-output analysis provide linear equations which describe relationships between resources (dollars), workload, and performance. These equations are incorporated into a goal programming model, which then determines the optimal allocation according to the assigned priorities. The model is computerized and is accessed interactively by the user.

ACKNOWLEDGEMENTS

Various personnel within the Systems and Cost Analysis Department at the US Army Logistics Management Center have participated in this study effort. These include MAJ Daniel A. Ryan, CPT Richard W. DeMouy, Mr. J. Allen Hill, Mr. O. John Erickson, Mr. Joseph D. Brannon, CPT Lonnie B. Adams, LT Gary L. Martin, Mr. Thomas A. Miller, and Mr. Gerald A. Klopp. Of these, special acknowledgement should be given to MAJ Ryan, who was responsible for the revamping of the Input-Output model and the Goal Programming algorithm. He made changes which contributed to the success of the DELTA 7S effort, and was the only member of the study team with Mr. Craddock after September 1978. MAJ Ryan wrote Annexes H (User Instruction) and I (Computer Program) of this report. Also, acknowledgement is due Mr. Hill for writing Annex B (Literature Survey).

Various other personnel assisted the study team in its endeavors. They include Mr. David Hodges and Ms. Joan Tackett of HQ DARCOM, and Mr. Don Ruth, Tim Sommons, and Ron Hulscher of DESCOM.

Last, but not least, a very special acknowledgement is due Mrs. Debbie Thompson for superb administrative support. She never tired of the countless drafts of briefing charts and reports.

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PART I

EXECUTIVE SUMMARY

1. Problem Statement

One of the most critical missions of the US Army Materiel Development and Readiness Command (DARCOM) is to ship materiel to some "user." Whether this "user" is a CONUS installation or an overseas activity, a shortage of required supplies and repair parts contributes directly to a decline in operational readiness. DARCOM's supply mission is funded by the Central Supply Subprogram, known as P7S, of the Operation and Maintenance, Army (OMA) Appropriation. In the past few years, increased fiscal constraints have been placed on the OMA Appropriation in general, and on P7S in particular. The historically accepted method of distributing changes in the budget (primarily decrements) has been to use a pro rata allocation. Pro rata cuts are no longer acceptable since there is no attempt to distribute the fund cuts in a "balanced" manner. A balanced allocation will take into account factors not usually considered in a pro rata allocation. It is possible that a better allocation can be made by assessing a larger percentage decrement against particular missions, with more essential missions cut a smaller percentage.

The DELTA 7S Study was initiated in April 1978 by the Deputy Commanding General for Resource Management at DARCOM to develop an improved methodology which would assist the resource managers in distributing changes in the P7S budget. The objectives of this study were threefold. First, the model must allocate the P7S budget in a balanced manner. Second, the model should determine the impact of this budget allocation on the wholesale supply system. This impact will be measured in changes

to workload and performance. Workload is broadly defined as how _much_ work the supply system must accomplish and is measured in such terms as procurement actions accomplished and requisitions processed. Performance is broadly defined as how _well_ the supply system accomplishes that workload, and is measured in such terms as stock availability and on-time requisition processing. A balanced allocation will consider the impact of fund changes on supply workload and performance. Third, the model should be able to perform the functions of allocation and impact determination when the funding for some programs is fixed.

2. Background

The Department of the Army (DA) informs its major commands (such as DARCOM) of their funding guidance periodically via the Program Budget Guidance (PBG). Annually, each major command prepares and sends to DA a budget which includes the budget estimate for the next two fiscal years as well as an update on the execution status of the budget for the current fiscal year. This budget, known as the Command Operating Budget Estimate (COBE), contains estimates for money and personnel requirements based upon both the previously received PBG and updated projections of workload. Under Zero-Based Budgeting, this budget estimate is stratified into several funding levels. These strata include projections of the workload possible based upon the funding expected to be received, and estimates of the funds required to accomplish the total workload projected. The difference between these two funding levels is sometimes referred to as the unfinanced requirement. The study team narrowly defined resources to imply funds

measured in dollars. Although resources also logically include personnel, physical space, etc., this narrow definition was chosen since money was the most critical constraint in P7S.

The P7S subprogram is divided into various program elements (PEs) which are split along functional lines, and when DA publishes the PBG, it assigns funds at the PE level. The sum of these PE dollar amounts represents the subprogram budget. Although it is difficult to increase the total subprogram amount, it is possible to shift some funds between PEs within P7S. The purpose of the DELTA 7S Study was to determine the impact of the DA fund allocation to the PEs in P7S (as indicated in the PBG) and also to determine various "strawman" allocations to maintain the balance between the various PEs, and improve the workload and performance of the supply system.

3. Assumptions

In the process of formulating this study, two major assumptions were made. These are:

(1) The supply system in DARCOM is a closed system that interacts with all "users" in the same manner. Specifically, the relationship between P7S and P7M, the Maintenance Subprogram of the OMA Appropriation, is assumed to be identical to the relationship with other CONUS or overseas installations. That is, the supply system operates essentially the same whether the shipped materiel goes to a using unit in Germany or across the depot to a maintenance activity.

(2) The unfinanced requirements in the COBE represent additional,

validated requirements and are not a wish list. Further, if funding were received for these additional requirements, the funds would be distributed as indicated in the COBE.

Other assumptions were made as the study progressed. These assumptions are discussed in the main report.

4. Methodology

The objectives of the study were translated into essential elements of analysis (EEA) which were specific questions that the study must answer. These questions were:

(1) What mathematical relationships exist between the program elements in P7S?

(2) How do funding changes affect the output of the various program elements in P7S?

(3) How should a change in the P7S budget be allocated in a balanced manner among the program elements?

These EEA, which were formulated at the beginning of the study, gave rise to additional questions as the study progressed. These additional questions will be discussed as appropriate.

An accepted approach for describing historical mathematical relationships is to apply regression analysis. The study group was severely limited in this aspect because only four data points were initially available (FY 74 to FY 77). Financial data prior to FY 74 were not compatible with data after that time because of a major change in the accounting structure in FY 74. Data from FY 78 were not available initially, but were obtained in the latter stages of the study and were

used for validation purposes. Regression equations were developed that described both workload and performance as a function of resources (dollars).

A popular theory at DARCOM is that performance is logically a function of both workload and resources. That is, how well one does something depends upon not only how much one must do (workload) but also how much is available with which to do it (resources). The exact relationship between resources, workload, and performance is a complex one, but an attempt was made to model performance as a function of both workload and resources using multiple regression. This approach did not work because of the small number of observations and the high correlation between workload and resources.

An attempt was made to base the final equation choices on both logic and mathematical fit. Using the sets of equations that were developed from four data points, the study group validated the equations with a fifth data point (from FY 78 data which were then available). The resulting sets of equations for workload and performance are the best equations available given the constraints of logic, mathematical fit, and predictive ability.

The data for these equations came from various DARCOM cost and performance reports, and from briefing charts (primarily on performance) prepared by the Materiel Management Directorate at HQ DARCOM. All cost data were adjusted to FY 78 constant dollars using inflation guidance published by HQ DARCOM.

The study team used input-output analysis to model the balance between the program elements in P7S. Input-Output (I-O) analysis is an econometric technique that describes the interrelationships between

various sectors of an "economy." In order to apply input-output analysis to the wholesale supply system, one must first consider it as a supply economy and identify the various support sectors and the final product of the economy. In this case, the final product of the supply economy is assumed to be the materiel that is shipped to some user. All other functions that do not directly relate to the shipping function are considered to be support functions. The Army Management Structure (AMS) codes provided a natural break for the support sectors. After several iterations, the following nine program elements or combinations of program elements were selected as the support sectors of the supply economy:

PROGRAM ELEMENT	FUNCTION
721111	Supply Depot Operations
721112	Supply Management
721113	Procurement
722829/722898	Command
722896.Z	Base Operations
728009	Transportation (First Destination)
728010/728013	Transportation (Second Destination)
728011	Industrial Preparedness
728012	Logistics Support

Two PEs were eliminated from the model because they are small and contain only reimbursable funds. These are PE 729998, Reimbursable GOCO Services, and PE 729999, Reimbursable Sale of Supplies. Some program elements were combined to insure compatibility with historical data. These combined PEs, in all cases, were only split apart recently.

To determine the relationships between the various support sectors and the final product, the study group first identified which functional relationships should exist between the various sectors. For example, what actions does a depot perform that support a National Inventory Control Point? The study group examined AR-37-100-78, looking at each AMS code to determine in which cell of the I-O matrix its function belonged. These relationships were quantified by using the dollars programmed for the different functions. Both the FY 79 Funded and Unfunded requirements were included to insure that the correct balance was modeled between the various program elements. These I-O relationships were formalized as equations which were used to represent the balance relationships.

Since this model is primarily a fund allocation model, the classical approach is to use a type of linear programming. Goal programming (GP) is a relatively new and more flexible variation of linear programming. The primary difference is that GP allows for several conflicting objectives or goals, and attempts to satisfy these goals in order of priority. For convenience, these goals are grouped into five areas. These areas are:

(1) Totally allocate the P7S budget.

(2) Assure that the funding levels for selected PEs are guaranteed via the "fencing" option. These PEs will be allocated, as a minimum, the amount of funds equal to their fence.

(3) Maintain a balanced relationship between the various program elements.

(4) Meet the workload as stated in the COBE.

(5) Achieve the DARCOM numerical goals for various performance indicators.

5. Model Output

The goal programming model is computerized and is accessed interactively. The output of the model comes in three pages. The first page of output displays the latest program budget guidance by direct, funded, and automatic reimbursable obligations for each of the PEs in the model. The program determines all of the totals, and then asks two questions of the operator. The first question is to identify any "fencing" that may be required for selected PEs. The second question verifies the total 7S budget.

The second page shows the comparison of COBE and model allocations for both direct and total obligations. The last page of the output shows the impact of both the COBE and model allocations on the workload and performance parameters. The predicted values are actually the expected values obtained from the workload and performance reqression equations. The difference column shows the difference between the predicted value and the goal. A negative difference implies underachievement.

6. Conclusions and Recommendations

In summary, this model does what it was intended to do. It not only provides the impact of DA funding guidance on supply workload and performance, but also provides an alternate or "strawman" allocation to improve workload and performance. This strawman considers the proper balance between program elements within P7S. The model also has the ability to fence selected PEs, that is, to insure that the model allocates a predetermined dollar amount to those "fenced" PEs. A real advantage is that the model can do these things with very short turn-around time.

The study team recommends that the Budget Operations Branch in the Comptroller Directorate at HQ DARCOM use the DELTA 7S model to analyze funding alternatives for FY 80 and FY 81. Further, someone at HQ DARCOM should be designated as a Point-of-Contact for the model. This person would be responsible for handling all questions on the operation and maintenance of the model.

PART II

MAIN REPORT

1. Problem Statement

One of the US Army Materiel Development and Readiness Command's prime missions is to function as the Army's wholesale supply system. The funds to operate this supply activity come from the Central Supply and Maintenance (Program 7) portion of the Operations and Maintenance, Army Appropriation. More specifically, the supply funds come from Subprogram 7S, (P7S), Central Supply Activities. The P7S subprogram (like other programs) is divided into various Program Elements that are essentially split along logical, functional lines. The PEs may also be further subdivided, and this is the basis for the Army Management Structure. (A more complete description of the P7S subprogram and its PEs is contained in Annex D.) The P7S subprogram has been a frequent target of budget changes (primarily decrements), and the "traditional" way to allocate these changes among the various program elements in P7S was based on pro rata shares. This allocation assumes that all of the PEs are of equal importance, although some PEs are clearly more critical than others.

This study was initiated to develop an improved methodology which would distribute changes in the P7S budget in a balanced manner. A balanced allocation will consider the contribution of each segment of the supply system. This methodology must also assess the impact of this balanced fund allocation on the supply system workload and performance. Workload will be defined, in general, as "how <u>much</u> work the supply system must accomplish." Performance will be defined, in general, as "how <u>well</u> the supply system accomplishes that workload." There are management indicators and goals for

both workload and performance variables. The methodology developed for this study is able to allocate proposed P7S budget changes and assess the predicted impact on supply workload and performance.

2. Background

As stated earlier, the traditional approach to budget decrements has been to assess pro rata cuts. That is, the various program elements are each decremented by the same fixed percentage. This implicitly assumes that all PEs are of equal importance, which may not be the case. Some program elements fund activities which deal with day-to-day operations (such as in a supply depot). These PEs have clearly defined and measured management indicators, and are sometimes referred to as the "hard" accounts. Other PEs fund activities whose impacts are long range (such as Industrial Preparedness Activities). These PEs tend to have less specific management indicators, and are sometimes referred to as the "soft" accounts. The descriptors "hard" and "soft" are not intended to be derogatory, but rather to indicate the dilemma that management faces. It may be more feasible to assess a lower percentage cut to those PEs where the impact will be felt immediately, and assess a higher percentage cut to those PEs where the impact will be delayed, perhaps for years. This should not be interpreted as a management "cop out." It essentially attempts to minimize the known, immediate impacts while delaying the less certain, long-range impacts.

However, to be able to do this in a defensible manner, one must be able to assess those known, immediate impacts quantitatively. Qualitative impact statements are becoming less useful in the current budget-strained environment. Recognizing this, the Deputy Commanding General for Resource

Management at HQ DARCOM initiated a study in April 1978 to develop a methodology which would assist managers with allocating the P7S budget changes in a balanced manner. This study, known as the DELTA 7S Study, had the following specific study objectives:

(1) Balanced allocation of changes in 7S funding.

(2) Effect of funding change on supply performance.

(3) Balance and effect when the funding for some elements is fixed.

These study objectives were then translated into Essential Elements of Analysis (EEA), which are specific questions that the study must answer. These are:

(1) What mathematical relationships exist between program elements in P7S?

(2) How do funding changes affect the output of various program elements in P7S?

(3) How should a change in the P7S budget be allocated in a balanced manner among the program elements?

These EEA gave rise to other specific questions as the study progressed, which will be discussed as appropriate.

3. Study Approach

Since this problem is basically a fund allocation model, the classical approach is to use some form of mathematical programming. Linear programming is the most common form of math programming, and there exists a large number of computer algorithms for solving these problems. However, the constraints that exist within the supply system would possibly lead to an infeasible solution in linear programming. Goal Programming is a

relatively new variation of linear programming in which several conflicting objectives or goals are possible. (In practice, GP problems are not restricted to a linear form. However, whenever references to GP appear in this report, they refer to a linear goal programming model.) The GP will satisfy as many of these goals as possible by looking at them each separately in a predetermined order of priority.

This study used GP as the basic model structure, and developed the linear objective equations using other techniques. Specifically, regression analysis and input-output analysis were used to establish linear equations which were later incorporated into the GP.

Since the model must determine the impact of the budget allocations on the supply system workload and performance, the study team had to develop the relationships between resources (R), workload (W), and performance (P). Although resources logically include dollars, personnel, space, time, equipment, etc., the study team restricted the meaning of "resources" to imply only dollars, the most critical resource variable. The relationships to be developed were:

$$W = f(R)$$

$$\text{and } P = f(W,R) \text{ or } P = f(R).$$

Linear regression analysis was the technique used because of the linear restriction of the GP chosen for the DELTA 7S model.

Input-Output analysis is an econometric technique which was used to model the balance between the various PEs in P7S. Input-Output analysis has traditionally been used to model the US economy. In order to apply

I-O to the problem at hand, the study team had to describe the Army's wholesale supply system as an economy. Once this was done, an I-O budget allocation matrix was prepared. Sets of linear equations were derived from this budget allocation matrix which describe the interrelationships of the various PEs in P7S. These linear equations were then incorporated into the GP with the regression equations described above.

4. Assumptions

In the process of model development, the study team had to make several assumptions. These assumptions include:

(1) The purpose of the supply system is to ship materiel to a user.

(2) The three main functions of a depot are to receive, store, and ship. The receipt and storage functions are actions that a depot performs in order to posture itself to ship.

(3) The unfunded requirement is a validated requirement, and does not represent a wish list.

(4) If funds were received at the enhanced level, DARCOM would distribute the funds as indicated in the Command Operating Budget Estimate (COBE).

(5) The supply system functions essentially the same whether the shipped materiel is going to some unit overseas or across the depot to a maintenance facility.

5. Data Base

Initially, the study team attempted to obtain detailed quarterly financial, workload, and performance data back to FY 74. Financial data

previous to FY 74 were not comparable because of a major change in the accounting structure from FY 73 to FY 74. Accordingly, the study team issued several data calls. The results of these data calls were either no data provided at all, or data which could not be combined. Consequently, the study team gathered its own data from official reports. Table 1 shows the various reports that were used. A summary of the data gathered is contained in Annex E. All data were inflated to constant FY 78 dollars using inflation guidance published by HQ DARCOM. The performance data were obtained from quarterly briefing charts prepared by the Evaluation Division of the Materiel Management Directorate at HQ DARCOM. The data for these charts came from MILSTEP.

SYMBOL	TITLE	DATA
CSCAB-205	Command Operating Budget Estimate	financial and workload projections
DRCCP-159	DARCOM Resource Management Report	financial
DRCMM-305	Depot Operations Cost and Performance Report	workload
DRCSU-207	Cost and Performance Plan and Report	workload
DRCRP-127	Central Procurement Report	workload
DRCMM-E	Quarterly Briefing Charts	performance and some workload

Table 1. Sources of Data

6. Model Description

As mentioned earlier, the DELTA 7S model consists of a Goal Program with linear equations from regression analysis and input-output analysis. The regression equations were developed from the data base contained in

Annex E. The workload equations all predict workload as a function of resources (dollars). Annual data from FY 74 to FY 77 were used initially, and those equations were validated with FY 78 data. The validation procedure is described in Annex G. After validation, FY 78 data were included in the data base. The equations in Table 2 are based on FY 74 through FY 78 data. The independent variable is given as the funds expended in those PEs in constant FY 78 dollars. In some cases, more than one PE is listed. These are not multiple regressions. Rather, they represent new variables created by physically summing the dollars in those PEs. The r^2 value is an indicator of how good the equation fits the data. A more detailed description of these equations (with coefficients) is contained in Annex C.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	r^2
Actions Initiated	721111 + 721112 + 721113	.75
Requisitions Processed--Total	721111 + 721112	.97
Tons Received and Shipped	721112 + 721113	.77
Line Items Shipped	721111	.95
Procurement Actions (PA)	721111 + 721113	.73
Total Procurement (PA + Backlog)	721111 + 721113	.73

Table 2. Workload Equations

The study team's initial premise was that performance is a function of both workload and resources. That is, how well you accomplish your work (performance) depends on both how much work you must do (workload) and

how much resources are available with which to do it (resources). To this end, the study team attempted to develop multiple linear equations which "predict" performance as a function of both workload and performance. The problem was that there were only four annual data points initially. Although this left only one degree of freedom, the equations were marginally acceptable because of the extremely high experimental F values. In an attempt to increase the number of data points, the study team investigated quarterly data (1 Qtr FY 76 through 2 Qtr FY 78, including FY 7T). However, the relationships that were developed using annual data could not be reproduced when quarterly data were used. The quarterly data had much too much variability/noise. In an attempt to decrease the variability, the statistical technique of a three quarter moving average was used, but this also did not produce satisfactory results. The data were also shifted one or more quarters based on the premise that resources in Quarter 1 may affect performance in Quarters 2 and 3. The data were also smoothed and shifted at the same time. None of these attempts produced statistically acceptable and logically explainable equations, so the study team decided to not use the quarterly data.

The annual equations with workload and resources as the independent variables were also not used, but not because of the degrees of freedom. The high correlation between the two independent variables was unacceptable. More specifically, the value for the workload "independent" variable was itself derived from an equation with resources as the independent variable. Logically, workload is a better predictor for performance than is resource.

However, the workload value is still based on resources. The use of workload to predict performance would constitute a two-step process with possibly increased variability. Therefore, the final equations predict performance as a function of resources. As with the workload equations, the performance equations were initially based on annual data from FY 74 to FY 77, validated with FY 78 data, and then revised to include the FY 78 data. The resulting equations are shown in Table 3. The details of these equations are contained in Annex C.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	r^2
NICP O-T Reqn Proc	721112	.87
Depot O-T Reqn Proc	721111	.71
O-T Receiving Rate--Reporting	721111	.78
O-T Receiving Rate--Stowing	721111	.86
Location Survey Accuracy	721111	.84
DARCOM O-T Trans Rate	721111	.76
Stock Availability Rate	ΣX_i except 728009	.66

Table 3. Performance Equations

As with any regression equation, the value "predicted" is really an expected value. It is rare to observe the predicted value exactly. Further, the variability between the predicted and the observed values is directly related to the number of data points used in the regression.

Input-Output analysis is an econometric technique most commonly used to measure the interrelationships between the various sectors of an economy. As an example of I-O applied to a military situation, consider the hypothetical DA budget that is shown in Figure 1. In this example,

the purpose of the Army economy is assumed to be the General Purpose Forces. Some of the DA budget can be directly attributed to this final product. However, some of the DA budget is consumed in activities which support the General Purpose Forces in an indirect manner. These support sectors in this example are Supply, Maintenance, Training, and R&D. Suppose that the total DA budget ($141 billion) were to decrease. Then the total dollars allocated to the various sectors would also decrease. For example, assume the maintenance budget decreased from 46 to 40 billion dollars. The various numbers in the maintenance row would also have to decrease so that they total 40 rather than 46 billion. Suppose to accomplish this the maintenance support to the supply sector (now at 3 billion) were decreased to 2 billion. Then the other inputs to the supply sector would also have to decrease proportionately in order to prevent an imbalance. The mathematics of input-output analysis allow one to take into account these sector interrelationships. In order to apply this technique to the supply system, one must determine what are the support sectors and the final product of this supply economy.

FROM \ TO	SUPPLY	MAINTENANCE	TRAINING	RESEARCH/ DEVELOPMENT	GENERAL PURPOSE FORCES	BUDGET DOLLARS. (BILLIONS)
Supply	4	2	1	3	40	50
Maintenance	3	2	1	5	35	46
Training	1.5	1	2	.5	20	25
Res/Dev	1.25	.50	1.50	1.75	15	20
				TOTAL ARMY BUDGET (BILLIONS)		$141

Figure 1. Allocation of a Hypothetical DA Budget

An assumption was made that the purpose of the supply economy is to ship material to some user, and that all functions which directly relate to the issue and shipping function are to be considered as the "final product," analogous to the general purpose forces in the previous example. The various PEs in P7S are split along functional lines, and represent a convenient description of the support sectors for the supply economy. These PEs are described in detail in AR-37-100-XX, The Army Management Structure. The XX refers to the specific fiscal year under consideration. Since FY 78 is the base year for this study, AR-37-100-78 was used. Only the PEs applicable to DARCOM (those contained in the COBE) were considered. Some of these PEs were also eliminated because they were small, reimbursable accounts. These include PE 729998, Reimbursable GOCO Services and PE 729999, Reimbursable Sale of Supplies. Some of the remaining PEs were combined because they were only recently split apart. Specifically, PE 722829, Logistics Administrative Support, was combined with PE 722898, Management HQ (Logistics). Also, the DARCOM portion of PE 728013, Overseas Port Units (Non-IF), was combined with PE 728010, Second Destination Transportation. These combinations were necessary in order to be compatible with previous data. One new PE was included: PE 728009, First Destination Transportation. Although this program element was not established until FY 79, it was included to be compatible with future budgets.

The resulting PEs and combinations of PEs form the support sectors of the supply economy. These are shown in Table 4.

The next step was to determine how the various PEs support each other and the final product. First, the study team identified the logical,

functional relationships that exist between the various PEs. For example, a supply depot (PE 721111) performs three major functions: receipt, storage, and shipping. The shipping function was previously mentioned as relating to the final product. An assumption was made that the receipt and storage functions are actions that a supply depot performs in order to posture itself to ship.

PROGRAM ELEMENT	FUNCTION
721111	Supply Depot Operations
721112	Supply Management
721113	Procurement
722829/722898	Command
722896.Z	Base Operations
728009	Transportation (First Destination)
728010/728013	Transportation (Second Destination)
728011	Industrial Preparedness
728012	Logistics Support

Table 4. Support Sectors

The study team then went through AR-37-100-78 in detail and evaluated the description of each PE at the lowest level to determine which sector that particular function would support. The dots in Figure 2 indicate those areas where relationships were identified. A more detailed description of what those dots represent is contained in Annex C.

Next, these dots were replaced by the dollar amounts shown in

SUPPLY ECONOMY
INPUT-OUTPUT RELATIONSHIPS

FROM \ TO	721111	721112	721113	722829/ 722898	722896.Z	728009	728010/ 728013	728011	728012	PRODUCT DELIVERED
721111	●	●	●			●	●			○
721112	●	●	●							
721113		●	●			●				
722829/98	●	●	●	●	●		●	●	●	
722896.Z	●	●	●	●	●		●	●	○	
728009	●									●
728010/13	●						●			○
728011			●					●		
728012	●	●	●	●	●		●	●	●	

Figure 2. Supply Economy
Input-Output Relationships

Figure 3. Two assumptions were made in compiling this matrix. First, the unfunded requirement is assumed to be a validated requirement and does not represent a wish list. Second, if funds were received at the enhanced level, DARCOM would distribute the funds as indicated in the COBE. The rationale for making these assumptions is the definition of balance between PEs. A balanced allocation considers the contribution of each PE to itself and the rest of the supply system. The total requirement should come closer to describing the proper ratios between PE funds than does the basic (funded) requirement. That is, since funds are constrained (DARCOM does not receive all the funds it needs), distribution of funds at the basic level may not be "balanced" due to external constraints.

The mathematics of input-output analysis allow one to derive linear equations which describe the sector interrelationships. The classical approach to I-O is to determine what inputs are required for an economy in order to achieve a desired output. That is,

$$(I - A)^{-1}F = X$$

where A is the matrix of technological coefficients based on the mathematical description of the economy,

F is the matrix of the economy output (such as Gross National Product),

I is the identify matrix,

and X is the matrix of the economy input required.

One set of linear equations was derived based upon this relationship. However, since the economy output desired, F, was an unknown, a second set

INPUT-OUTPUT BUDGET ALLOCATION TABLE
(FY 79 FUNDED AND UNFUNDED REQUIREMENTS)*
(FY 78 $ 1000's)

FROM \ TO	721111	721112	721113	722829/ 722898	722896.7	728009	728010/ 728013	728011	728012	PRODUCT DELIVERED
721111	194159	22814	2578			6847	6847			154362
721112	11885	148942	16128							
721113		29274	121401			9759				
722829/98	26399	12052	10927	84913	16421		25	12131	11730	
722896.Z	22086	31624	28671	31203	64853		66	31830	30778	
728009	6565									43935
728010/13	9060						370			60634
728011			13440					164666		
728012	10748	4907	88464	4842	6687		10	4939	51627	

*BASED UPON FY 79/80 COBE

Figure 3. *Input-Output Budget Allocation Matrix (FY 78 $ 1000's)*

of linear equations was necessary. A more detailed description of these equations is contained in Annex C.

As was mentioned previously, the overall model structure is based upon goal programming. The linear equations developed using regression analysis and I-O form the constraints in the GP. As an example of how the individual goals are formulated, consider the following equation:

$$-3773.5 + .0327X_1 = \text{Line Items Shipped}$$

where X_1 = dollars in PE 721111.

This equation is one of the workload equations discussed previously. The usual way to use this equation is to choose some value for X_1 and then "predict" the number of line items to be shipped. However, in GP this would be formulated slightly different. The GP approach to this problem is to predetermine a value desired for line items shipped (the goal), and then allow the difference between the predicted value of line items shipped and the goal to be absorbed in "deviations." Consider the following:

$$-3773.5 + .0327X_1 + d^- - d^+ = \text{GOAL for line items shipped}$$

where X_1 = dollars in PE 721111

d^- = the negative (underachievement) deviation; i.e., the number of line items below the GOAL

d^+ = the positive (overachievement) deviation; i.e., the number of line items above the GOAL

GOAL = the stated goal for the number of line items to be shipped

In this case, the goal was taken from the COBE, which stated this workload requirement as $5646.9(10^3)$ line items shipped.

In GP, the value of X_i will be chosen that will minimize the deviations from the stated goal. In practice, there are many equations all of which cannot be satisfied at the same time. The algorithm will then attempt to minimize these various deviations in a prespecified order of priority.

For convenience, the goals for the DELTA 7S model are grouped into five categories:

(1) Totally allocate the P7S budget. This goal consists of a single equation that says that the summation of all of the PEs must equal the P7S budget amount. Deviations above or below this budget amount are not permitted.

(2) Assure that the funding levels for selected PEs are guaranteed via the "fencing" option. This goal consists of an equation for each PE to be "fenced" at a certain funding level. The GP will not permit deviations below these specified funding levels. These equations are structured so that "fencing" a PE will establish a minimum funding level permitted. Otherwise, this minimum funding level is set at zero dollars.

(3) Maintain a balanced relationship between the various program elements. This goal consists of two sets of linear equations derived from the input-output model.

(4) Meet the workload as stated in the COBE. This goal consists of a series of linear regression equations which predict workload as a function of dollars.

(5) Achieve the DARCOM numerical goals for various performance indicators. This goal consists of linear regression equations which predict performance as a function of dollars.

Each goal equation must have priorities assigned to its deviational variables (d^- and d^+). The two deviational variables may have different priorities, if desired. For example, consider the equation for the "totally allocate the P7S budget" goal described previously. This goal consists of a summation of the funds expended in each of the PEs. The overachievement deviational variable, d^+, represents the dollars spent over the P7S budget total. The underachievement deviational variable, d^-, represents the underspending difference in dollars between the P7S budget and the P7S projected expenses. It may be far more important to avoid an overspending than an underspending, in which case the d^+ would have a higher priority than would d^-. A more detailed description of the priority structure is contained in Annex C.

One important feature of the priority structure is the "fencing" provision. This consists of a series of equations that establishes goals of spending at least a minimum amount for each PE. In the absence of a fence, this minimum amount is zero dollars. This minimum can easily be changed to a positive amount for any PE at the beginning of the model exercise. This is an important feature to insure compliance with external or internal funding directives. For example, the Congress directed that a certain amount be spent on Industrial Preparenesss Activities (PE 728011) in FY 79. This is translated into an equation that states PE 728011 be funded at a minimum equal to the Congressional directive. The underachievement deviational variable has a very high priority in this instance.

7. Model Application

DARCOM receives funding guidance in the form of the Program Budget

Guidance (PBG) periodically from HQ DA. The PBG used in the exercise of this model is the FY 79 PBG dated 16 Jan 79. Table 5 displays this PBG by PE in P7S. Note the small reimbursable accounts such as PE 729998, Reimbursable GOCO Services, have been eliminated as previously discussed. These dollar amounts are in FY 79 dollars, and are converted by the model program to FY 78 dollars to be compatible with the goal programming equations. Although the PBG reflects funding guidance at the PE level, some reprogramming of funds between PEs is allowable. It is also possible to reprogram between P7S and other subprograms, but the DELTA 7S model does not attempt this. The DELTA 7S model will take the budget total for P7S and allocate to the various PEs without regard for the PBG. This new allocation of funds is intended to be a strawman alternative to the PBG.

			REIMBURSABLE		
	PROG ELEM	DIRECT	FUNDED	AUTOMATIC	TOTAL
1	721111	255,784	21,042	2,034	278,860
2	721112	117,732	216	38,800	156,748
3	721113	107,190	100	23,938	131,228
4	722829	69,105	0	3,412	72,517
5	722898	87,766	0	4,713	92,479
6	722896.Z	181,080	1,000	37,286	219,366
7	728009	65,500	0	0	65,500
8	728010	44,733	0	0	44,733
9	728011	77,982	0	438	78,420
10	728012	108,625	1,454	38,726	148,805
11	728013	388	0	0	388
		1,115,885	23,812	149,347	1,289,044

Table 5. Program Budget Guidance for FY 79 ($000)
(dated 16 January 1979)

The model is computerized, and the output comes in three pages. The first page, shown in Figure 4, prints the latest PBG. The funds for each PE are divided into direct obligations, funded reimbursable obligations, and automatic reimbursable obligations. The rational for this breakout is that most of the funding changes occur to the direct obligations during the budget execution year. This feature will allow the model user to readily analyze possible budget changes. Once the PBG is printed, the model asks two questions of the user. The first question concerns the fencing options. Recall that a "fence" establishes a minimum funding level for a particular PE. By default, the minimum funding level for each "non-fenced" PE is set at zero dollars. In the example in Figure 4, PE 728009, PE 728010/13, and PE 728011 were fenced at the PBG level. The second question allows the user to change the total funding level from that authorized by the PBG. This feature is intended to allow the user to quickly analyze what-if questions concerning total P7S funds. The user would eventually have to readjust the PBG for the various PEs until their sum equaled the new total budget.

Once these two questions have been answered the model then allocates the total budget. The results are displayed by PE for both direct and total obligations. The PBG allocations are also shown under the columns labeled "COBE." These allocations are displayed in the second page of output, and are shown in Figure 5. Note that the model allocations for PE 728009, PE 728010/13, and PE 728011 are equal to the COBE/PBG allocations. This is because these PEs were fenced at the PBG level. Note also that the model allocated more funds to PE 721111, PE 721112, and PE 721113, than did the PBG.

```
:FILE FTN01=PRIOR22,OLD
:FILE FTN02=COBE4,OLD
:RUN ALLOCATE
```

	PROG ELEM	DIRECT	REIMBURSABLE FUNDED	REIMBURSABLE AUTOMATIC	TOTAL
1	721111	255784.	21042.	2034.	278860.
2	721112	117732.	216.	38800.	156748.
3	721113	107190.	100.	23938.	131228.
4	722829	69105.	0.	3412.	72517.
5	722898	87766.	0.	4713.	92479.
6	722896.Z	181080.	1000.	37286.	219366.
7	728009	65500.	0.	0.	65500.
8	728010	44733.	0.	0.	44733.
9	728011	77982.	0.	438.	78420.
10	728012	108625.	1454.	38726.	148805.
11	728013	388.	0.	0.	388.
	TOTALS	1115885.	23812.	149347.	1289044.

```
IF YOU WISH TO 'FENCE' A PE VALUE, ENTER ITS ROW
NUMBER AND THE DOLLAR VALUE(IN THOUSANDS) SEPARATED
BY A COMMA. WHEN NO FURTHER 'FENCING' IS DESIRED,
ENTER 0,0 ?7,65500

ENTER NEXT 'FENCE' OR 0,0 ?8,45121

ENTER NEXT 'FENCE' OR 0,0 ?9,78420
```

Figure 4. Model Output--Page 1

```
ENTER NEXT 'FENCE' OR 0,0 ?0,0

ENTER THE TOTAL FUNDS AVAILABLE (IF THIS IS
TO BE THE SAME AS THE TOTAL ABOVE, ENTER 0 ) ?0

END OF PAGE 1 ?
```

PROG ELEM	DIRECT COBE	DIRECT MODEL	TOTAL COBE	TOTAL MODEL
721111	255784.0	283820.4	278860.0	306896.4
721112	117732.0	125390.0	156748.0	164406.0
721113	107190.0	124473.0	131228.0	148511.0
722829/98	156871.0	129860.1	164996.0	137985.1
722896.Z	181080.0	152186.8	219366.0	190472.8
728009	65500.0	65500.0	65500.0	65500.0
728010/13	45121.0	45121.0	45121.0	45121.0
728011	77982.0	77982.0	78420.0	78420.0
728012	108625.0	111551.2	148805.0	151731.2
	1115885.0	1115884.5	1289044.0	1289043.8

```
END OF PAGE 2 ?
```

Figure 5. Model Output--Page 2

These three PEs fund the "hard" accounts, as discussed previously and these PEs also are used most often as the independent variables in the workload and performance equations. The funds for these increases came from some of the "soft" accounts. Specifically, the model attempted to first significantly reduce PE 728011, then PE 728009, and finally PE 728010/13. These PEs were fenced at the PBG level to prevent this.

The third page of the output contains the impact of the COBE and model allocations on the workload and performance variables. This is displayed in Figure 6. The GOAL column contains the goals for the various equations in the goal program. The goals for the workload equation came from the COBE, and the goals for the performance equations came from the DARCOM numerical goals for performance indicators. The "PRED" column is the result of taking the dollar amounts from the various PEs and plugging into the workload and performance equations previously discussed. The "DIFF" column is the result of subtracting the goal from the predicted value. A negative difference indicates an underachievement, and a positive difference indicates an overachievement. Note in Figure 6 that the model differences are in general better than the COBE differences. This is because the model allocates more funds to PE 721111, PE 721112, and PE 721113, than does the PBG. These PEs were used as the independent variables in most of the equations. Not all negative workload differences are bad, however. Some of the workload goals represent the enhanced level as opposed to the basic (funded) level. All of the predicted workload and performance variables are actually expected values since they are the results of a regression equation. The actual, observed values in FY 79

PARAMETER		GOAL	COBE PRED	COBE DIFF	MODEL PRED	MODEL DIFF
NO. ACTIONS INITIATED	(K)	1251.1	815.6	-435.5	1353.3	102.2
REQN. PROCESSED TOTAL	(K)	3953.3	3207.5	-745.9	3857.3	-96.0
TONS RECEIVED & SHPD	(K)	3046.4	2308.2	-738.2	3046.4	.0
LINE ITEMS SHIPPED	(K)	5646.9	4786.3	-860.6	5646.9	.0
PROCUREMENT ACTIONS	(K)	119.4	98.4	-21.0	123.2	3.8
TOTAL PROC(PA+BACKLOG)	(K)	171.8	116.0	-55.8	160.9	-10.9
HICP OT REQN. PROC.	(%)	89.0	78.3	-10.7	90.5	1.5
DEPOT OT REQN. PROC.	(%)	89.0	89.7	.7	78.9	-10.1
DARCOM REC. RATE-REPT.	(%)	90.0	93.7	3.7	85.2	-4.8
DARCOM OT REC.-STOW.	(%)	85.0	89.5	4.5	76.1	-8.9
DARCOM OT TRANS. RATE	(%)	83.0	70.2	-12.8	81.3	-1.7
LOCATION SURVEY ACC.	(%)	98.0	97.3	-.7	95.5	-2.5
STOCK AVAIL. RATE	(%)	85.0	73.0	-12.0	72.9	-12.1

```
END OF PAGE 3
 IF YOU WANT TO MAKE FURTHER CHANGES, ENTER A 1
 ANY OTHER ENTRY WILL TERMINATE THE PROGRAM.   ?
```

Figure 6. Model Output--Page 3

will probably be different even though some of the funds may be the same as programmed. Thus, it is dangerous to draw conclusions based on the absolute differences between numbers. It is valid only to look at the relative magnitude of differences.

The general priority structure that resulted in this allocation in shown in Table 6. A more detailed discussion of the priority structure is contained in Annex C. As the priority structures change, so do the model results. In general, the major conflicts are between the I-O balance equations and the workload/performance equations for reasons discussed previously. Historical DARCOM allocations appear to resemble the allocations based on the balance equations rather than the workload/performance equations. In fact, the model allocation is almost identical to the PBG when only the balance equations are included. For these reasons, the balance equations are placed at a higher priority than the workload/performance equations in most priority structures.

PRIORITY	GOAL
1	Totally allocate the P7 Budget
2	Fencing
3	Balance
4	Balance
5	Workload/Performance

Table 6. General Priority Structure

8. Conclusions and Recommendations

The model has several limitations. First, the supply system is treated as a "closed" economy, with the output of the economy being

materiel that is shipped to some user. The relationship between P7S and P7M is treated explicitly by considering P7M as another "user" of items. Some people feel that P7S cannot be separated from P7M. Second, the workload and performance equations are based on historical data (FY 74 to FY 78), and assume that these relationships are valid for succeeding fiscal years. In other words, the model assumes that DARCOM will not make drastic changes in its management philosophy for the wholesale supply system. Another model limitation is the sensitivity of the model allocations to the priority structure. This sensitivity is not bad, per se, given the user is familiar enough with the model operation, to understand the effects of changing the priority structure. In practice, this should not be a limitation because the user should be very familiar with the model.

The model also has several advantages. First, it seeks to make an optimal allocation of the budget for a given priority structure. In essence, it allocates the funds to achieve as many priority goals as possible. Second, the technique used to allocate the funds (goal programming) is defensible as an accepted methodology. Third, the model is interactive and operates in real time. Finally, the model gives the impact of the budget allocations on various workload and performance parameters.

In summary, the model not only satisfies the study requirements, but also does it on an interactive terminal display. It not only provides the impact of DA funding guidance on supply and performance, but also provides an alternate or strawman allocation to improve workload and performance. This strawman considers the proper balance between PEs within P7S. The model also has the ability to fence selected PEs; i.e., to insure that the

model allocates a predetermined dollar amount to those fenced PEs. The model has been transferred to the Supply Section of the Budget Operations Branch in the Comptroller Directorate, HQ DARCOM. The program is operational, and is accessed via remote terminals.

The DELTA 7S model can be a very useful tool for assisting management in analyzing budget alternatives. In fact, the model should be used to analyze several different funding alternatives so that management has several options from which to choose. The study team recommends that the Budget Operations Branch in the Comptroller Directorate use the DELTA 7S model to analyze funding alternatives for FY 80 and 81. Further, someone at HQ DARCOM should be designated as a Point-of-Contact for the model. This person would be responsible for handling all questions on the operation and maintenance of the model.

ANNEX A

ADMINISTRATIVE DOCUMENTS

ANNEX A

ADMINISTRATIVE DOCUMENTS

This annex contains the major documents that describe the administrative conduct of the study. A Study Directive was never prepared for this study. Rather, the Proposed Study Concept on page A-3 was the response to a verbal tasking by HQ DARCOM. This proposed study concept was briefed to the Deputy Commanding General for Resource Management on 20 April 1979. The result of this briefing was a decision to proceed with the study as outlined. Although the Proposed Study Concept was never formalized, it nonetheless served as the Study Plan.

Mr. J. Allen Hill was the initial study team leader. However, he was selected for Long Term Training early in the conduct of the study and Mr. William T. Craddock was designated as the study team leader. A Memorandum for Record describing this is on page A-9. Finally, a brief chronology of the study conduct is on page A-10.

PROPOSED STUDY CONCEPT

Title: Impact of Incremental Changes in 7S Funding on Supply Performance (Delta 7S Impact: DELTA 7S)

Memorandum For: Deputy Commanding General for Resource Management, HQ DARCOM

1. References:

a. 7 Apr 78, DCGRM, MG Bergquist, discussed need and limits of this study effort with US Army Logistics Management Center representatives.

b. 7 Apr 78, Director, PTFD, BG Forney, verbally tasked ALMC to initiate this study effort.

c. Administrative and Procedural References:

(1) AR 5-5, The Army Study System

(2) DARCOMR 11-1, Systems Analysis

d. AR 37-100-78, The Army Management Structure

e. AR 37-59 (Rescinded Dec 77), Command Analysis Of Operations and Maintenance, Army, Funding

f. AR 700-126, Logistics: Basic Functional Structure

g. Reports (See Annex A)

2. Purpose: There is a need to relate the many, diverse OMA funded functions to performance indicators. The proposed study will relate the effects of incremental changes in funding for supply functions to supply performance in order to improve the capability to articulate requirements for resources.

3. Study Sponsor: Deputy Commanding General for Resource Management, HQ DARCOM

Points of Contact: Mr. Don Camp, DCGRM
ATTN: DRCDRM-TG
AUTOVON: 284-9343/9388

Mr. Tony Haver, ANAD
ATTN: SDSAN-PPA
AUTOVON: 694-7575

4. Study Agency: US Army Logistics Management Center
School of Management Science
Systems and Cost Analysis Department

Points of Contact: Mr. J. Allen Hill, Team Chief, AUTOVON 687-2027/4572
Mr. William T. Craddock, AUTOVON 687-2386/2442
Mr. John Erickson, AUTOVON 687-2027
CPT Rich DeMouy, AUTOVON 687-4572

5. Study Advisory Group (SAG): A SAG will be established.

6. Terms of Reference:

a. Background. DARCOM continues to experience declining funding levels in OMA accounts especially in relationship to Research and Development and Procurement funding levels. It appears that while RDTE and PAA funding will continue to increase that OMA funding will remain relatively constant or will be reduced. The decrements in OMA funding have not been balanced between supply (7S) and maintenance (7M) in such a way that supply could adequately respond to maintenance requirements. As a result, the DCGRM has initiated two study projects in order to gain an insight into the problem. The Army Materiel System Analysis Agency is tasked with identifying the relationship which should exist between the PAA, RDTE, and OMA portions of the budget. AMSAA will compare the historically requested funding levels with actual funding levels. A major assumption in the analysis is that the COBE describes a desirable balance among budget categories. The US Army Logistics Management Center is tasked with identifying the impact of funding changes (primarily decrements) in supply (7S) on the supply performance indicators. The proposed studies will provide the framework and basic methodology required for subsequent analysis of the four areas listed below:

(1) the impact of supply funding changes on maintenance (7M) performance factors,

(2) the impact of changes in maintenance funding (7M) on maintenance performance factors,

(3) the interrelationships between levels of 7S and 7M funding, and

(4) the impact of supply and maintenance funding changes on the readiness condition of the US Army.

b. Objectives of this Study: The primary objective of this study is to establish a method of analyzing the impact of incremental funding changes in supply funding (7S) on supply performance indicators. The methodology developed will produce management information useful to commanders in assessing tradeoffs among 7S program elements so that:

(1) the incremental changes can be applied among program elements in a balanced manner,

(2) the effect of the incremental funding changes can be related to key supply performance indicators, and

(3) the above analyses can be performed when some program elements are "fenced" at a given level.

c. Scope. The study will address a one year funding horizon rather than a FYDP for DARCOM supply (7S) funding. The methodology will be year independent (however, the parameters in the model may be year dependent).

d. Limits. The study will be limited to changes in the level of funding for DARCOM supply functions.

e. Time Frame. The study will use the FY 77 or FY 78 time frame (dependent on data availability) for development of the methodology. Upon validation, the methodology will be used to address FY 80 funding levels.

f. Assumptions:

(1) The DARCOM FY 78 COBE describes a desirable balance among budget categories and within the program elements of supply (7S) funding.

(2) Computer programming and computer time required for data extraction, data analysis, and validation of the methodology will be made available by HQ DARCOM.

g. Essential Elements of Analysis.

(1) What relationships exist between program elements in 7S

(2) How do funding changes affect the output of various program elements in 7S

(3) How should a change in the 7S budget be allocated in a balanced manner among the program elements

h. Steps in the Analysis:

(1) A literature survey supplemented by visits to other analytical agencies will be performed to determine the approaches and results of prior and ongoing studies in related areas.

(2) Methodologies will be developed to:

(a) allocate funding changes among 7S program elements in a balanced manner

(b) relate funding changes to changes in supply performance indicators, and

(c) to perform the above analysis when some program elements are fixed at a given level.

(3) Data suitable for exercise and validation of the methodology will be collected by FY 77 and FY 78 as appropriate.

(4) The methodology will be validated.

(5) Data for FY 80 will be collected and used to exercise the methodology to provide command information for action.

i. Models/Techniques. Several types of analytical techniques will be evaluated for possible use in analyzing this problem. Anticipated useful methodologies are:

(1) Regression/correlation analysis to determine the empirical relationships between funding levels and performance indicators.

(2) Descriptive and/or inferential statistical models will be used to determine sensitivity of data.

(3) Leontief's Input/Output Analysis model may be used to determine first and higher order relationships among funding levels within the supply budget.

(4) Goal Programming may be used to determine optimal relationships among funding levels for 7S program elements.

The above listed models/techniques represent the present assessment of those which hold promise for the solution of the problem; however, other models/techniques will be used if found to be efficacious.

7. Support and Resource Requirements:

a. Travel and per diem funds in the amount of $8,000 are required for accomplishment of this study and will be obtained through normal budget channels.

b. Representatives from the following organizations may be required to participate in the study on an ad hoc basis.

(1) Comptroller, HQ DARCOM

(2) Materiel Management, HQ DARCOM

(3) Procurement and Production, HQ DARCOM

(4) Development and Engineering, HQ DARCOM

(5) HQ DESCOM

c. Computer programming and computer time for data extraction and processing will be required. ALMC computer resources will be used to the maximum extent possible; however, some data extraction and attendant programming may be required of DARCOM agencies.

8. Administration:

a. Study Title. Impact of Incremental Changes in 7S Funding on Supply Performance.

Short Title. Delta 7S Funding

Acronym. DELTA7S

b. Study Schedule. The proposed study schedule and milestone chart are attached as Inclosure 1.

c. Control Procedures. A Study Advisory Group (SAG) should be established to monitor the study approach and emerging results. It is recommended that members of the SAG also monitor the AMSAA study for possible coordination of ideas and results.

d. Action Documents. The study will provide the following products:

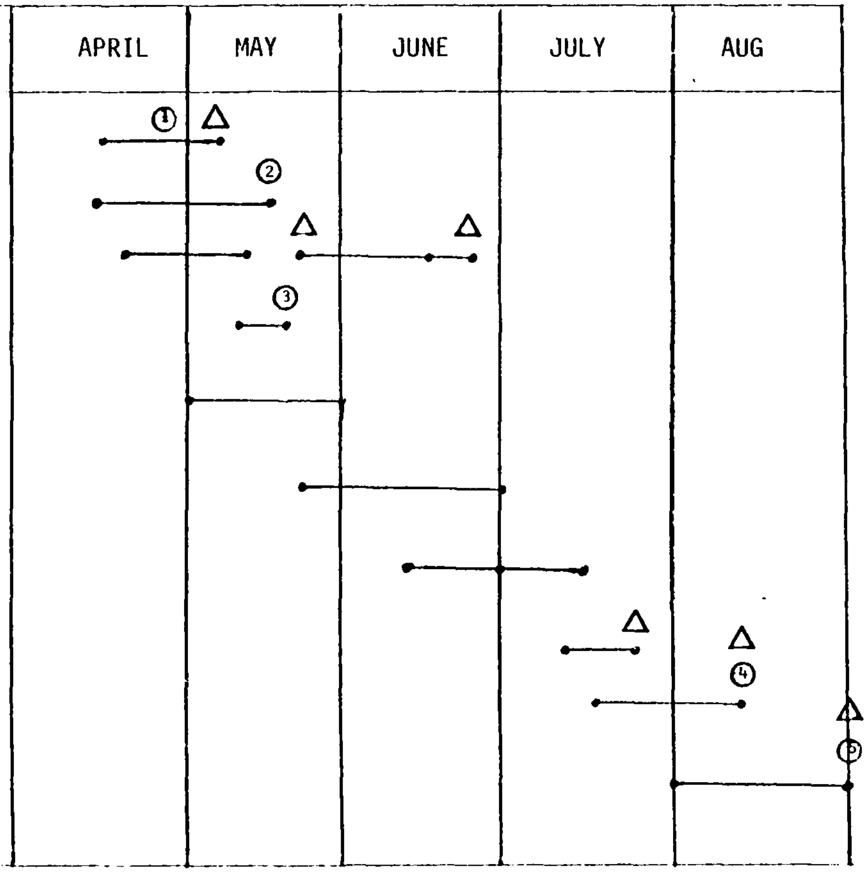
(1) A final study report, and

(2) Documentation of recommended methodologies.

PROPOSED STUDY MILESTONE CHART TIME FRAME: 13 Apr - 31 Aug 78

Title: Impact of Incremental Changes in 7S Funding on Supply Performance

Milestone and Products	Man Months
1. Study plan completed	.5
2. Literature Search	1.5
3. Data collection	4
4. Develop data collection instruments	1
5. Develop methodological approach	2
6. Computer programming	2
7. Exercise and validate methodology	3
8. Analyze FY 80 data	1
9. Write final report	2
10. Document methodology	2
Total	19



1 Study plan and milestone chart
2 Summary of literature search
3 Data collection plan
4 Final study report
5 Documentation of methodology

In process review

C O P Y

DRXMC-C-SCAD 31 July 1978

MEMORANDUM FOR RECORD

SUBJECT: DELTA 7S Study and Long Term Training for J. A. Hill

1. On Tuesday, 25 July 78, Mr. Hill was informed that he had been selected for long term training beginning in August 78. Mr. Hill contacted LTC Flynn, DCGRM Executive Officer, and asked him to determine if MG Bergquist would have any objections to Mr. Craddock assuming leadership of the DELTA 7S study as of 7 Aug 78. LTC Flynn indicated that Mr. Craddock and Mr. Hill should visit his office on 26 July to discuss this matter with MG Bergquist.

2. On Wednesday, 26 July 78, LTC Flynn stated that he had informed MG Bergquist of the situation. MG Bergquist has no objection to Mr. Craddock assuming leadership of the study. A meeting with MG Bergquist was not required.

3. Mr. Craddock is fully capable of leading the study to a successful conclusion. He was selected as a member of the study team due to his capability and in anticipation that this situation could arise.

J. ALLEN HILL
Chief, DELTA 7S Study

C O P Y

DELTA 7S CHRONOLOGY

7 Apr 78	ALMC tasked to perform DELTA 7S Study
20 Apr 78	Study Concept/Plan Approved
16 May 78	In-Process Review (Methodology)
22 Jun 78	Information Briefing, DARCOM Baseline Study Working Group
29 Jun 78	In-Process Review
7 Aug 78	Mr. Craddock designated as study team leader
8 Aug 78	Informal discussions with study sponsor
15 Aug 78	Information breifing, DRCMM-305 Working Group
8 Sep 78	In-Process Review
9 Nov 78	In-Process Review
21 Nov 78	Information Briefing, Comptroller, DARCOM
Nov 78-Feb 79	Informal discussions with Comptroller personnel
14 Dec 78	Information briefing, P7S Program Directors
Dec 78-Feb 79	Informal discussions with Materiel Management Personnel
16 Feb 79	Information briefing, Director of Materiel Management DARCOM
5 Mar 79	*Decision briefing, Deputy Commanding General for Resource Management, DARCOM

*The result of this briefing was that the Comptroller Directorate was to use the DELTA 7S model in analyzing the P7S budget during various budget exercises. ALMC was to perform no additional work on refining the DELTA 7S methodology.

ANNEX B

LITERATURE SURVEY

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LITERATURE SURVEY

The study team performed a fairly extensive literature search and conducted indepth interviews with knowledgeable functional personnel. Those studies, reports and texts which were found to be of interest are briefly described in this Annex. Most of the references for the studies/ reports are available through either the Defense Logistics Studies Information Exchange (DLSIE) or the Defense Documentation Center (DDC).

1. Textbooks.

a. Chenery, Hollis B. and Paul G. Clark, Interindustry Economics, John Wiley and Sons, New York, 1966.

The book presents a unified discussion of interindustry techniques and their empirical applications. The main concern is with substantive conclusions about the structure and performance of an economy that can be derived using the interindustry approach. Theoretical models that appear best suited to the analysis of policy problems and that use existing statistical materials are stressed.

b. Lee, Sang M., Goal Programming for Decision Analysis, Auerbach Publishers, Philadelphia, 1972.

Goal programming allows ordinal solution to a system of complex multiple (usually competing) objectives. This book presents goal programming as a decision analysis technique for problems with multiple goals under complex environmental constraints. The book addresses the underlying concepts, solution methods and applications to goal programming. The goal programming computer program listed in this book, as modified by the study team and the US Army Concepts Analysis Agency, was used in performing the DELTA 7S Study.

2. Studies/Reports.

a. Title: Study of Effects of Alternate Allocation of Army Dollar Resources at Various Budget Levels--Phase II--Final Report (CAA-SR-78-3, March 1978).

Study Agency: US Army Concepts Analysis Agency

Sponsor: DA, PAE

Summary: The ADRA II Study establishes a functional relationship (at an aggregate level) between the Army's budget and a measure of the Army's combat capability. The two-step process uses input-output analysis and combat effectiveness (WUV) algorithms. An input-output model (13 support and 6 output sectors) is developed for each of the 15 Army appropriations. The algorithms then allocate a static measure of the Army's combat effectiveness (WUV score) among output sectors. The change in WUV score are used as input to a combat simulation model which gives the potential change in combat capability.

Reference: CAA Report, CAA-SR-78-3

b. Title: Measuring the Impact of Force Structure Changes on Army Central Supply and Maintenance Resource Requirements (IDA Paper 962, June 1973).

Study Agency: Institute for Defense Analysis, Cost Analysis Group

Sponsor: OSD, PAE

Summary: The study examines existing Army methods to compute P7 resource requirements. It relates logistic-support variables to total resource requirements in specified program elements. The feasibility

studies were done at AVSCOM and TACOM. The study identified variables that appear to relate P7 resource expenditures to force structure. The study also indicated feasibility of approach, but lacked sufficient data to develop a comprehensive model.

Reference: DLSIE, LC 33271A; DDC, AD-A003021

c. Title: A Methodology for Estimating the Central Supply and Maintenance Resource Requirements (IDA Paper 1059, September 1974).

Study Agency: Institute for Defense Analysis, Cost Analysis Group

Sponsor: OSD, PAE

Summary: The study developed Cost Estimating Relationships (CERs) which relate P7 resource requirements (dollars and manyears) to force structure oriented variables, weapon system active inventory, strength of the Army, and number of active Army battalions. The study made the following conclusions:

(1) Army cost/workload systems are oriented towards logistics-support functions rather than weapon and support systems; however, data are available for depot maintenance.

(2) Current resource requirement estimating techniques do not permit rapid estimation of impact of force structure changes.

(3) The study developed CERs for 81 percent of P7 OMA resource requirements. The estimates are highly correlated with actual data and budgets (FY 74, FY 75). The average active inventory is the best CER predictor for depot maintenance. The strength of the Army is the best CER predictor for PE 721111 and PE 721112. The PE 721112 is the best independent variable for PE 721113.

Reference: IDA Paper 1059.

d. Title: An Army Logistics Support Information System (IDA Paper 1110, March 1975).

Study Agency: Institute for Defense Analysis, Cost Analysis Group

Sponsor: OASD, PAE

Summary: The study provides an information system to be used by OASD/PAE in obtaining data on a regular basis from Army logistics cost and reporting systems. These data will permit OASD/PAE to maintain current the IDA developed methodology for estimating Army central supply and maintenance resource requirements. The methodology was designed to be used in studies of defense resource allocations related to proposed alternative Army force structures. The information system must provide forecasts of the appropriate resource sensitive force-structure-oriented variables, as well as pertinent historical data. The identification of organizations as sources for elements of data is based on the IDA experience in developing the initial data base used to construct the P7 cost estimating methodology in IDA Paper 1059, "A Methodology for Estimating Army Central Supply and Maintenance Requirements."

Reference: DLSIE, LD 35036A; DDC, AD-016272.

e. Title: Logistics Resources Data Base Structure (January 1977)

Study Agency: General Research Corp., McLean, VA

Sponsor: PA&E Directorate, Office of the Chief of Staff, US Army

Summary: The study was initiated to develop an improved Army logistics data base structure for determining and displaying logistics resources allocated to, consumed by, and projected for units, weapons systems and logistics functions. The study made the following conclusions:

(1) Neither the FYDP program elements nor the AMS codes provide a meaningful or useful identification of logistics resources, other than in Program 7.

(2) The logistics resources structure is relatable to the FYDP and the logistics output requirements.

(3) Automated data base gaps may necessitate additional reporting requirements or other data acquisition techniques.

(4) An automated system is the most effective approach to the establishment of the required data base.

Reference: DLSIE, LD 38524A

f. Title: An Initial Feasibility Demonstration of the Army's Logistic Resource Annex (LRA) to the Five Year Defense Program (FYDP), GRC Report CR-205, January 1978.

Study Agency: General Research Corporation, McLean, VA

Sponsor: Program Analysis and Evaluation Directorate, Office of the Chief of Staff, US Army.

Summary: The Five Year Defense Program is not configured to display the logistics resources in many of its program elements. For example, in many cases, a single logistics function consists of resources from several program elements, or conversely, the resources in one PE can be applied to several logistics functions. The objective of the study was to accomplish three major tasks: (1) design a Logistics Resource Annex (LRA) to the FYDP, (2) develop the structure and methodology to construct an LRA, and (3) demonstrate the feasibility of the LRA concept.

The general methdology employed was to develop a two-dimensional matrix with logistic related resources allocated to force units as the rows, and specific combat battalion types as the columns. The method of filling the matrix "cells" consisted of: (1) extraction of logistic function totals from the FYDP using various factoring methods, (2) separation of Force and Non-Force related resources, and (3) attribution of logistic functional resources to force units or non-force units via appropriate attribution factors. The development of the various factors employed in steps (1) and (3) is contained in the body of the report. In many cases it is simply the ratio of the size (or amount) of a particular force (or program element dollar amount) to the total. In other cases, more complex factoring techniques are used. The report concluded that:

(1) It is possible to prepare an LRA, either manually (6 to 8 weeks of effort) or by automated means provided that there exists simultaneous availability of the FYDP and related documents.

(2) The factors for Supply Support, Maintenance, and Transportation do not change. That is, no significant changes in division size units occur in the force structure.

(3) The factors used can be validated using future FYDP data.

(4) Automation of the system is highly desirable.

Reference: DLSIE, LD 41188A.

g. Title: An Exploratory Input-Output Model for Support Cost Estimates (September 1976)

Study Agency: None. Thesis by Clemente Pionilla Mariano

Sponsor: Naval Postgraduate School, Monterey, California

Summary: This thesis develops a cost model to estimate support costs in the Phillipine Army. Leontief's input-output technique is appraised for applicability and is related to cost analysis techniques. The use and validation of proxy variables is presented. Correlation analysis is discussed as a tool for choosing a valid proxy variable. The matter of fixed costs and treatment in the cost model is addressed. Using hypothetical data, an example of the use of the model in the Phillipine Army setting is presented. Support units, tactical forces, and budgetary programs comprise the major elements of the system in the cost model.

Reference: DLSIE, LD 38136A; DDC, AD-A032254

h. Title: An Input-Output Analysis of the US Navy (May 1971)

Study Agency: US Naval Academy - Trident Scholar Project Report Forrester William Isen.

Summary: This report sets forth the basic aspects of input-output analysis and explores the problems involved in implementing input-output analysis of the US Navy. The original work was done to formulate a method for locating hotspots or bottlenecks in an economy using the basic input-output matrices. Special emphasis was given to non-price oriented economics, of which the military services are prime examples.

Reference: DLSIE, LD 27065

i. Title: Budget Justification Model (11 November 1975). "Response Time Technical Memorandum #40."

Study Agency: US Naval Fleet Material Support Office, Supply System Performance Evaluation Office

Sponsor: Naval Supply Systems Command

Summary: The cost-benefit model documented in this technical memorandum suggests an approach to related resources allocated to the logistics system to combat readiness. The model presented related operational availability and combat readiness to material and personnel resources available to the supply system. Reliability, availability, maintainability, and system response time and resource levels are the primary inputs to the model. The model is conceptually valid; however, attempts to derive data to support the model were unsuccessful.

Reference: DLSIE, LD 33353MA

ANNEX C

MODEL DESCRIPTION

ANNEX C

MODEL DESCRIPTION

The major analytical techniques used in the DELTA 7S Model are regression analysis, input-output (I-O) analysis, and goal programming. As discussed in the main report, the overall model structure is a goal program, with most of the equations obtained from regression or I-O analysis. Each of these three major analytical techniques are discussed in more detail in the remainder of this annex.

Regression Analysis. Regression analysis is a technique which allows one to develop the mathematical equation that best describes a given set of data. This equation can then be used to make statements about future observations of data. Since the equations developed for the DELTA 7S model were to be used in a linear goal program, the study team used only linear regression analysis. As discussed in the main report, the study team developed equations based on annual data from FY 74 to FY 78. These workload and performance equations were initially developed based on four annual data points (FY 74 to FY 77), validated based on a fifth annual data point (FY 78), and then revised to include all five data points. The validation procedure is described in more detail in Annex G. The final equations are shown in Table C-1.

The dependent variable in Table C-1 is identified by both a variable number and name. The variable number is the number by which that variable is identified in the master data file. Those variable numbers which begin with a "5" are resource variables. The workload variables begin with a "6", and the performance variables begin with a "7". The five annual points (FY 74 to FY 78) for each of these variables are contained in Annex E.

DEPENDENT VARIABLE		INDEPENDENT VARIABLE		EQUATION COEFFICIENTS		STATISTICS	
NUMBER	NAME	NUMBER	SYMBOL	INTERCEPT	SLOPE	r^2	t
603	Actions Initiated	511	$X_1 + X_2 + X_3$	-4938.1	0.01081	.75	3.01
604	Requisitions Processed--Total	509	$X_1 + X_2$	-4723.7	0.01939	.98	11.26
616	Tons Received & Shipped	510	$X_2 + X_3$	-6215.1	0.03152	.77	3.19
610	Line Items Shipped	501	X_1	-3773.5	0.03269	.95	7.91
612	Procurement Actions	517	$X_1 + X_3$	-126.5	0.00058403	.73	2.82
614	Total Procurement	517	$X_1 + X_3$	-289.9	0.0010542	.73	2.84
709	NICP O-T Reqn Processing *	502	X_2	-171.9	0.00170	.87	4.44
711	Depot O-T Reqn Processing	501	X_1	187.2	-0.00037248	.71	-2.73
714	O-T Receiving Rate--Reporting	501	X_1	169.8	-0.00029074	.78	-3.28
715	O-T Receiving Rate--Stowing	501	X_1	222.3	-0.00050722	.86	-4.31
717	Location Survey Accuracy	501	X_1	113.7	-0.000062653	.84	-3.95
713	O-T Transportation Rate	501	X_1	-30.0	0.00038271	.76	3.07
701	Stock Availability Rate	515	$\sum_{i=1}^{9} X_i$ except X_6	-26.0	0.000086127	.66	2.44

Table C-1. Workload and Performance Equations

*O-T stands for "on-time"

The independent variable in Table C-1 is identified by a variable number and a symbol. The variable number was discussed in the previous paragraph. The symbol X_i represents the funds expended in a particular Program Element. These symbols are explained in Table C-2. For some equations the independent variable is shown as the sum of several different resource variables. For example, the independent variable of the "Actions Initiated" equation is $X_1 + X_2 + X_3$. This is still a simple linear regression equation in which a new variable is created by physically summing the dollars expended in the PEs represented by X_1, X_2, and X_3. Although the independent variable number for this equation is 511 (which Annex D shows is the sum of PEs 721111, 721112, and 721113), the actual equation represents these as X_1, X_2, and X_3. That is, the equation for Actions Initiated (Y) is

$$Y = -4938.1 + 0.01081(X_1 + X_2 + X_3)$$

$$\text{or } Y = -4938.1 + 0.01081X_1 + 0.01081X_2 + 0.01081X_3$$

These equations also assume the X_i are in the FY 78 dollars, since the data used to develop equations were in constant FY 78 dollars. The computer program automatically converts the Program Budget Guidance (which is now in FY 79 dollars) to FY 78 dollars.

The intercept and slope coefficients are shown for each equation in Table C-1. Also shown are the r^2 and t statistics. The coefficient of determination, r^2, is a measure of how good the equation fits the observed data. A value of $r^2 = 1$ would imply that all of the observed data lie on the line described by the equation. The coefficient of correlation, r, is the square root of r^2. The sign of r is the same as the t value, and

a negative r implies that the variables are inversely proportional. That is, if X and Y have a negative r value, X increases as Y decreases, and vice versa. Note that four of the performance equations (dependent variable numbers 711, 714, 715, and 717) have negative correlation coefficients. This seems to imply, on the surface, that performance decreases as resources increase. However, this phenomenon can be explained.

SYMBOL	PROGRAM ELEMENT	FUNCTION
X_1	721111	Supply Depot Operations
X_2	721112	Supply Management
X_3	721113	Procurement
X_4	722829/722898	Command
X_5	722896.Z	Base Operations
X_6	728009	Transportation (First Destination)
X_7	728010/728013	Transportation (Second Destination)
X_8	728011	Industrial Preparedness
X_9	728012	Logistics Support

Table C-2. Independent Variables for Regression Equations

Suppose, as a means of explanation, that a depot's manpower standard is 500 "filled orders" per worker per year, and that the depot has 10 workers. Thus, the depot is expected to produce 5,000 "filled orders" annually. The fallacy here is that manpower standards are based solely on workload, and do not consider performance. Suppose that this hypothetical depot does produce the 5,000 "filled orders," but that the on-time processing rate for these orders is 80%, whereas the management goal is

90% on-time processing. Further, suppose that this depot is authorized two additional workers. If this depot is now expected to produce 6,000 "filled orders," the on-time processing rate will probably not improve, and may even degrade a little. If the depot is expected to produce 6,500 or more "filled orders" with only the two additional workers, its on-time processing rate will probably decrease.

Although this hypothetical example is oversimplified, a similar situation may have existed in DARCOM in the past few years. An investigation of the data in Annex E shows that both resources and workload, in general, have increased in the past five years. However, workload may have increased more than resources so that overall performance is declining. The equations cannot capture this phenomenon mathematically because of the small number of data points.

The t values in Table C-1 are experimental statistics used to test the hypothesis that the theoretical slope is equal to zero. There are three degrees of freedom associated with these data, and at the 0.10 level of significance, the critical value of t is 2.353. Another test of hypothesis that can be performed is that the theoretical coefficient of determination is equal to zero. The F statistic is used to test this hypothesis, where F is approximately the square of the experimental t value.

As was discussed in the main report, an attempt was made to increase the number of data points by using quarterly data from 1 Qtr FY 76 to 2 Qtr FY 78. Although this produced eleven data points (including FY 7T), the study team could not duplicate many of the equations originally developed using annual data. Assuming that this was due to noise in the quarterly

data, the study team attempted to smooth the data using several methods. These attempts included using a three-quarter moving average, shifting the workload and performance data one or more quarters following the resource data, and a combination of shifting the three-quarter moving averages. By this time the data were extremely disguised, and the decision was made to use only the annual data.

The original premise of the study team is that performance is logically a function of both workload and resources. Although these were initially only four data points, the study team developed several performance equations from multiple linear regression using workload and resources as the independent variable. Although these equations had only one degree of freedom, the experimental F values were extremely high. These equations were discarded because of the high correlation between workload and resources. In fact, the numerical value for the workload independent variable would itself come from a simple linear regression equation with resources as the independent variable. A decision was made to use only resources or combination of resources, as the independent variable. The resulting equations, shown in Table C-1, represent the best compromise between mathematical fit and functional logic (based on discussions with HQ DARCOM personnel).

Input-Output Analysis. Leontief's input-output analysis is a classical technique used by economists to determine the interrelationships between various "sectors" of an economy and the "final users." In economic applications, the sectors might typically be various industries such as agriculture, steel, and mining. The model assumes that the product of

each sector is partially consumed by itself and the other sectors. The remaining product is distributed to the final users. Examples of final users are domestic consumption and export. The model information is displayed by means of a matrix or tableau.

To use the I-O model, one first determines the "gross transactions" between the various sectors and the final users. That is, the total output from each sector is allocated to itself, the other sectors, and the final users. When these data are displayed in a matrix, it is called the gross transactions matrix. The model then "normalizes" this gross transactions matrix by dividing each value in a particular column by the corresponding row sum. The row sum is the result of adding the gross transaction in a particular row, say the agriculture sector. Then each gross transactions value in the agriculture column is divided by the agriculture row sum. This procedure is repeated for all of the sectors.

The result of this normalizing effort is the "A" matrix. This A matrix considers only the "first order" effects, and ignores any indirect demand made on one sector by its consumption of the output of another sector. These higher order effects are accounted for mathematically by computing the $(I - A)^{-1}$ matrix. This matrix accounts for the ripple effects in an economy.

In order to apply input-output analysis to the Army's Wholesale Supply System, the study team had to describe the supply system as an economy. The product of this economy was assumed to be materiel shipped to some user. All activities which relate to the issue and shipping functions were considered as the final users of the economy. The program

element structure of the Army Management Structure provides a logical, functional description of the sectors of this supply economy. The PEs generally fund activities which are related. A more detailed description of these PEs is contained in Annex D. The PEs that were chosen to represent the sectors of the supply economy are listed in Table 4 of the main report. Note that this list combines some PEs and completely omits others. Specifically, PE 722829 (Logistics Administrative Support) and PE 722898 (Management HQ Logistics) were combined since they were only recently split apart, and the historical data (FY 74 to FY 78) shows these PEs as one account. Also, the DARCOM portions of PE 728010 (Second Destination Transportation) and PE 728013 (Overseas Port Units--Non-IF) were only recently split apart. In this case, PE 728013 funds a small group of personnel at Tobyhanna Army Depot who monitor the world-wide movement of containers. The PEs in P7S which are not shown in Table 4 were eliminated from the model because they were either not applicable to DARCOM or contain only small funds as compared to the other PEs. An example of a PE not applicable to DARCOM is PE 728018 (Real Estate and Construction Administration). The basis for this statement is the absence of this PE from the DARCOM COBE. An example of a PE which contains only a small amount of funds is PE 729998, Reimbursable Small Business Administration (SBA) Development costs.

In order to determine the sector relationships, the study first made several assumptions about the functional relationship between the activities funded by a particular PE and the various sectors of the supply economy. For example, a supply depot (PE 721111) performs several major

functions, including the receipt, storage, and shipment of materiel. Since the final product of this supply economy was assumed to be materiel shipped to some user, the issue and shipping functions are activities that the depot performs in support of the final user. The corollary to this is that the receipt and storage functions are activities that a depot performs in order to posture itself to ship materiel, and would therefore be functions that a supply depot performs in support of itself.

The study team then went through AR-37-100-78 in detail to determine what similar relationships would hold for other PEs. Each PE was evaluated based upon the smallest accounting subdivision of the PE. The study team made assumptions about what each of the Program Element Activity Accounts (PEAA) would support. The result was Figure 2 in the main report. The dots in this matrix represent those sector combinations where a functional relationship was found. The composition of each of these dots is explained in Table C-3, which shows which sectors each PEAA supports. The data in this table have been aggregated where possible. For example, the PEAA 721111.11 (Receipts) is not further subdivided in Table C-2, although the accounting structure provides for further subdivisions. The 'x' for each PEAA indicates its functional relationship. Occasionally, a particular PEAA will support more than one sector. For example, PEAA 721111.123 (Bin Issue) is assumed to support both PE 721111 and the final product or product delivered. In this case, 25 percent of the output of PEAA 721111.123 will support PE 721111, and 75 percent of the output of PEAA 721111.123 will support the product delivered. These percentages are based on discussions

with Depot Systems Command (DESCOM) and HQ DARCOM personnel. Some of the PEAAs are prorated across several of the support sectors. This is identified with a "P" under the appropriate support sectors. Also, some of the PEAAs are further clarified with notes at the end of Table C-3.

Table C-3. AMS Code/Input-Output Sector Relationships

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
721111.0	SUPPLY DEPOT OPERATIONS	x											
.1	Storage and Warehousing	x											
.11	Receipts			x									
.12	Packing & Issue	x											
.121	Packing	x											
.1211	Packing for Shipment												x
.1212	Packing for Storage			x									
.122	Bulk Issue												x
.123	Bin Issue			.25									.75
.124	Shipping												x
.129	Packing & Issue Support												x
.13	Storage Support	x											
.131	Care of Materiel in Storage			x									
.132	Rewarehousing			x									
.133	Preservation and Packaging	x											
.1331	Shipment												x
.1332	Storage			x									

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
721111.134	Container Assembly of Mfgr												x
.135	Unit and Set Assembly												x
.136	Inventory			.3	.7								
.137	Training			x									
.138	Special Processing of non-ASF			x									
.139	General Storage Support			x									
.14	Other Storage Support	x											
.141	Bulk Fuel and Lube Oil			x									
.143	Quality Control	x											
.1431	Receiving Inspection			x									
.1432	Cyclic Inspection			.10	.90								
.1433	Preservation, Packaging, & Packing	x											
.14331	Ammo-COSIS			x									
.14332	Ammo-Ship/Rec	x											
.143321	Receiving			x									
.143322	Shipping												x
.14334	General Supplies-COSIS			x									

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
721111.14335	General Supplies-Ship/Rec	x											
.143341	Receiving			x									
.143352	Shipping												x
.1434	Shipping Inspection												x
.1435	Other Quality Control			x									
.144	Transshipment												x
.16	Special Processing of Conv. Ammo			x									
.19	General Storage & Warehousing Support			x									
.2	Stock Control	x											
.21	Requisition Processing			.50	.25	.25							
.22	Other Stock Control Operations			.50	.25	.25							
.23	Stock Control Support				x								
.3	Traffic Management	x											
.31	Freight								.5	.5			
.32	Passengers			x									
.33	Household Goods			x									
.34	Training			x									

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
721111.39	Traffic Management Support			x									
.9	Overall Supply Depot Support			x									
.Y9999	Base Closure/RIF			x									
721112.0	SUPPLY MANAGEMENT OPERATIONS	x											
.1	Inventory Control	x											
.11	Commodity Management				.80	.20							
.12	Requirement Computation				.80	.20							
.13	Other Inventory and Log Spt				x								
.2	Logistics Data Management				x								
.4	Stock Control	x											
.41	Requisition Processing			.70		.30							
.42	Inventory Acctg and Stock Control			.10	.90								
.5	Training				x								
.9	Supply Management Operations Support				x								
.Y9999	Base Closure/RIF				x								

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
721113.0	CENTRAL PROCUREMENT ACTIVITIES	x											
.1	Procurement Operations				.30	.60			.10				
.2	Contract Administration Operations					x							
.3	Quality Assurance for Central Proc Activities					x							
.Y9999	Base Closure/RIF					x							
722829.0	LOGISTICS ADMINISTRATIVE SUPPORT	x											
.1	System/Program/Project Product Mgt						x						
.2	Dispersed Activities						x						
722896.Z	BASE OPERATIONS, CENTRAL SUPPLY ACT		1	R	P	P	P	P		P	P	P	
722898.0	MANAGEMENT HQ (LOGISTICS)		2	P	P	P	P	P		P	P	P	
728009.0	FIRST DESTINATION TRANSPORTATION		3	.13									.87
728010.0	SECOND DESTINATION TRANSPORTATION		3	.13									.87

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722829/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
728011.0	INDUSTRIAL PREPAREDNESS OPERATIONS	x											
.1	Plants										x		
.2	Equipment										x		
.3	Industrial Base Management					.5					.5		
.79999	Base Closure/RIF										x		
728012.0	LOGISTIC SUPPORT ACTIVITIES	x											
.1	Other Logistics Services	x											
.11	Attendant Central Supply Services			P	P	P	P	P		P	P	P	
.12	Production Engrg-ASF excl food					x							
.13	Standardization Programs					x							
.14	Production Engrg-ASF Clothing & Equip					x							
.16	Production Engrg-Procurement Items					x							
.17	Production Engrg-ASF Uniform Bd Items					x							
.18	Mission Support Aircraft			P	P	P	P	P		P	P	P	
.19	Production Engrg-DOD food program					x							
.2	Preparation for and Disposal of Property											x	

Table C-3. AMS Code/Input-Output Sector Relationships (Cont'd)

CODE	FUNCTION	Further Subdivided	NOTE	721111	721112	721113	722892/98	722896.Z	728009	728010/13	728011	728012	Product Delivered
728012.79999	Base Closure/RIF											x	
728013.0	OVERSEAS PORT UNITS (NON-IF)	x											
.1	General Terminal Support									x			
.2	Cargo Handling												x

NOTES

1. The "R" under 721111 stands for Residual BASOPS. The dollar amount is available from DESCOM. The remaining 722896.Z is prorated among the remaining PEs except 728009 and 728010. These are excluded because they fund commercial transportation.

2. The PE 722898 is prorated among all PEs except 728009 and 728010.

3. The 13%/87% split is based upon the fact that approximately 13% of all new procurement from contractors goes to the depots. The rest goes directly to the users.

The gross transactions matrix shows how the output of each sector is consumed by itself, the other support sectors, and the final users. A problem encountered in applying I-O analysis to the supply economy is the difficulty in determining the economic output of each sector. For this reason, dollars expended (or programmed) for the different PEs (support sectors) were used as proxy variables in lieu of the economic output of each PE. The result is a budget allocation matrix rather than a gross transactions matrix. This budget allocation matrix, shown in Figure 3 of the main report, is based upon both the funded and unfinanced requirements for FY 79. The assumptions behind this inclusion of the unfinanced requirement are discussed in the main report. The COBE data for this matrix are contained in Table C-4. Since neither the COBE nor the PBG provides information at the AMS detail in Table C-3, various existing reports which do have the detail necessary were employed to establish ratios for dividing the PE totals. The actual allocation of the funds in Table C-4 is shown in Figure C-1. The end result of these allocations is Input-Output Budget Allocation Table, shown in Figure 3 in the main report. This budget allocation table will be used as a proxy for the gross transactions matrix.

The budget allocation table is "normalized" by first determining the sum of each row. In this case, each row sum should equal the total requirement for that PE in Table C-4. Each of the support sector columns is then divided by its respective row sum. For example, the sum of the values in the first row (PE 721111) of Figure 3 of the main report is 387607, and each value in the first column (PE 721111) is divided by this amount. Thus,

	BASIC DIRECT	BASIC REIMB	BASIC TOTAL	UNFINANCED REQT 1	UNFINANCED REQT 2	TOTAL UNFINANCED REQT	TOTAL REQT
721111	239,724	22,024	261,748	47,734	78,125	125,859	387,607
721112	115,187	39,353	154,540	7,102	15,313	22,415	176,955
721113	102,724	23,650	126,374	8,846	25,214	34,060	160,434
722829	70,687	2,779	73,466	6,032	---	6,032	79,498
722896.Z	172,225	36,144	208,369	9,109	23,633	32,742	24,111
722898	90,594	3,519	94,113	987	---	987	95,100
728010	58,445	---	58,445	5,718	5,531	11,249	69,694
728011	62,369	438	62,807	24,726	90,573	115,299	178,106
728012	99,786	37,002	136,788	21,027	14,409	35,436	172,224
728013	370	---	370	---	---	---	370

Table C-4. FY 79 COBE Requirements (CSCAB-205 Report, July 1978)

A. Allocation of 721111

Sector	%1/	$
721111	.5009167	194,159
721112	.0588578	22,814
721113	.0066506	2,578
728009	.0176649	6,847
728010/13	.0176649	6,847
Prod Del	.3982451	154,362
		387,607

1/ These percentages were obtained from the 4QTR FY 77 DRCSU-238 Report. Specifically, the cumulative FY 77 civilian manhours for each PEAA were allocated to each sector in lieu of dollars. These PEAA totals were then converted to the percentages used above. The values used were:

Sector	MH	%
721111	10,050,559	.5009167
721112	1,180,942	.0588578
721113	133,440	.0066506
728009	354,435	.0176649
728010	354,435	.0176649
Prod Del	7,990,521	.3982451
	20,064,332	1.0

Figure C-1. Allocation of COBE Requirements in I-O Matrix

B. Allocation of 721112

Sector	% 2/	$(000)
721111	.0671646	11,885
721112	.8416930	148,942
721113	.0911424	16,128
		176,955

2/ These percentages were obtained from the 4QTR FY 77 DRCSU-207 Report. Specifically, the cumulative FY 77 dollars expended for each PEAA were used as proxy variables, and allocated to each sector. These PEAA totals were converted to percentages as follows:

Sector	$(00)	%
721111	97,739	.0671646
721112	1,224,846	.8416930
721113	132,632	.0911424
	1,455,217	1.0

C. Allocation of 721113

Sector	% 3/	$(000)
721111	.060827	9,759
721112	.182469	29,274
721113	.756704	121,401
		160,434

3/ These percentages were obtained from the 4QTR FY 77 DRCCP-159 Report. Specifically, the FY 77 cumulative total dollars expended were used as proxy variables and allocated to each sector. These PEAA totals were converted to percentages as follows:

Sector	$(000)	%
721111	5,183	.060827
721112	15,548	.182469
721113	64,478	.756704
	85,209	1.0

Figure C-1. Allocation of COBE Requirements in I-O Matrix (Cont'd)

D. Allocation of 722829/98

PE 722829 all goes to 722829/98

79498 TOTAL

PE 722898 is prorated to all PEs except 728009

Sector	FY 79 $(000)	%	$(000)
721111	387,607	.277595	26,399
721112	176,955	.126731	12,052
721113	160,434	.114899	10,927
722829/98	79,498	.056935	5,415 + 79,498 = 84,913
722896.Z	241,111	.172678	16,421
728010/13	370	.000265	25
728011	178,106	.127555	12,131
728012	172,224	.123343	11,730
	1,396,305		95,100

Figure C-1. Allocation of COBE Requirements in I-O Matrix (Cont'd)

E. Allocation of 722896.Z

Residual Basops to 721111 $22,086 K in FY 79 per FONECON with DESCOM, 10 Oct 78

BASOPS from COBE	241,111	
	- 22,086	Residual to 721111
	219,025	
	- 55,020	722896.NXX (Administration)
	164,005	To be prorated

Sector	FY 79 $(000)	%	BASOPS	
721112	176,955	.192823	31,624	
721113	160,434	.174821	28,671	
722829/98	174,598	.190255	31,203	
722896.NXX	55,020	.059954	9,833	+ 55,020 = 64,853
728010/13	370	.000403	66	
728011	178,106	.194077	31,830	
728012	172,224	.187668	30,778	
	917,707		164,005	

Figure C-1. Allocation of COBE Requirements in I-O Matrix (Cont'd)

F. Allocation of 728009

Sector	%	$(000)
721111	.13	6,565
Prod Del	.87	43,935
		50,500

FY 79 PBG dtd 22 Dec 78
$50,500K for PE 728009

G. Allocation of 728010

Sector	%	$(000)
721111	.13	9,060
Prod Del	.87	60,634
		69,694

H. Allocation of 728011

.1 Plants	29,041	
.2 Equipment	16,927	
.3 Planning	16,839	
	62,807	Basic '79
	115,299	Total UFR
	178,106	Total Reqt

UFR1	24,726	
UFR2	90,573	2514
	115,299	1153
		6375
		10,042 planning in UFR2

Sector

721113 ··· planning = .5(16,839 + 10,042)
= .5(26,881)
= 13,440

728011   178,106 - 13,440 = 164,666

Figure C-1. Allocation of COBE Requirements in I-O Matrix (Cont'd)

I. Allocation of 728012 $172,224 K FY 79 COBE

728012.11	33,452
728012.18	4,523
	37,975 to be prorated

Sector	$(000)	%		
721111	387,607	.2830457	10,748	
721112	176,955	.1292194	4,907	
721113	160,434	.1171551	4,449	+ 84,015 = 88,464
722829/98	174,598	.1274982	4,842	
722896.Z	241,111	.1760686	6,687	
728010/13	370	.0002702	10	
728011	178,106	.1300599	4,939	
728012.2	50,234	.0366828	1,393	+ 50,234 = 51,627
	1,369,415		37,975	

in addition,	.12	25,131
	.13	18,047
	.14	0
	.16	35,754
	.17	1,058
	.19	4,025
		84,015

J. Allocation of 728013

$370 K all goes to 728010/13

Figure C-1. Allocation of COBE Requirements in I-O Matrix (Cont'd)

the value in the "from 721111/to 721112" cell is 11885 divided by 387607, or 0.030663. This procedure is repeated for each of the support sectors; the product delivered is disregarded after the row sums are calculated. the result of this "normalization" is a square matrix. If this matrix is referred to as the A matrix, then an element of the matrix, a_{ij}, represents the proportional amount of the output of sector i consumed by sector j. Since the output of each sector which is not consumed by itself or the other sectors is consumed by the final users (F) the following matrix equation is applicable:

$$AX + F = X$$

where X is a column matrix of the Total Requirements in the COBE.[1] For example, X_1 is the total requirement for PE 721111, X_2 is the total requirement for PE 721112, etc. The matrix AX is the amount of the total requirement consumed by the support sectors. Thus, this equation is partitioning the total requirement into that consumed by the support sectors and that consumed by the final users:

$$(A - I)X + F = 0$$

where I is the identity matrix and 0 is a column matrix with all zeroes. This equation results in a series of nine linear equations, which are listed in Table C-5. The X_i are those defined in Table C-2.

[1] The notation used here is based on that used by Dr. Harold E. Fassberg in his address to the Operations Research Systems Analysis Executive Course (ORSAEC) at the US Army Management School at Fort Belvoir, VA. The transcript of his presentation, Input-Output Analysis and Linear Programming, was used at one time as a handout for the ORSAEC.

Sector	Equation
721111	$-0.499083X_1 + 0.128925X_2 + 0.016069X_3 + 0.135584X_6 + 0.135584X_7 + F_1 = 0$
721112	$0.030663X_1 - 0.158306X_2 + 0.100527X_3 + F_2 = 0$
721113	$0.165432X_2 - 0.243296X_3 + 0.193248X_6 + F_3 = 0$
722829/98	$0.068108X_1 + 0.068108X_2 + 0.068109X_3 - 0.513666X_4 + 0.068106X_5 + 0.000357X_7 +$ $0.068111X_8 + 0.068109X_9 + F_4 = 0$
722896.Z	$0.056980X_1 + 0.178712X_2 + 0.178709X_3 + 0.178713X_4 - 0.731024X_5 + 0.000942X_7 +$ $0.178714X_8 + 0.178709X_9 + F_5 = 0$
728009	$0.016937X_1 - 1.0X_6 + F_6 = 0$
728010/13	$0.023374X_1 - .994719X_7 + F_7 = 0$
728011	$0.083773X_3 - 0.075461X_8 + F_8 = 0$
728012	$0.027729X_1 + 0.027730X_2 + 0.551404X_3 + 0.027732X_4 + 0.027734X_5 + 0.000143X_7 +$ $0.027731X_8 - 0.700233X_9 + F_9 = 0$

Table C-5. Linear Input-Output Analysis Equations

The "traditional" way to use input-output analysis is to use the above equation to solve for X. That is,

$$X = (I - A)^{-1}F$$

where F is the known, desired output to the final users. In the case of the supply economy, the F matrix is an unknown. Thus, the F_i in Table C-5 are also unknowns. This necessitated an additional series of nine linear equations. These additional equations were generated by assigning the values of the FY 79 funded requirement to the above X_i values, and solving for the F_i values. Thus,

$$F = (I - A)X$$

This is readily accomplished by assigning the X_i in the equations of Table C-5 the values of the funded (Basic) requirements in Table C-4, and solving for the F_i. The results of this are shown in Table C-6. These equations are also included in the Goal Program. Note that the equations for F_3 and F_8 will require the addition of artificial variables in the Goal Program. (These artificial variables will also appear in the equations in Table C-5 which contain F_3 and F_8.)

The equations in Tables C-5 and C-6 are included in the goal program to represent the balance between the various program elements.

Goal Programming. Goal programming is an extension of linear programming which allows for more than one objective or goal. These multiple objectives may be conflicting; i.e., not all of the objectives can be fully satisfied at the same time. In linear programming, this situation would result in an infeasible (unsolvable) solution. In GP,

these goals or objectives would be ranked, and then satisfied in order of priority. That is, if two goals are conflicting, the higher priority goal will be fully satisfied before the lower priority goal.

Sector	Equation
721111	$F_1 = 96084.5159$
721112	$F_2 = 3734.631218$
721113	$F_3 = -4578.596576$
722829/98	$F_4 = 21313.36721$
722896.Z	$F_5 = 21532.32872$
728009	$F_6 = 46066.77412$
728010	$F_7 = 52386.30023$
728011	$F_8 = -5847.250075$
728012	$F_9 = 2380.61988$

Table C-6. Additional I-O Equations

In a GP, the goals are each represented as a constraint, and deviational variables are used in lieu of slack variables. The objective function is to minimize the deviational variables. As an example, consider the equation for Line Items Shipped that was discussed in the main report:

$$-3773.5 + 0.0327X_1 = \text{Line Items Shipped}$$

where X_1 = dollars in PE 721111.

In the GP, this equation is represented as

$$-3773.5 + 0.0372X_1 + d^- - d^+ = \text{GOAL for Line Items Shipped}$$

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IMPACT OF INCREMENTAL CHANGES IN 7S FUNDING ON SUPPLY PERFORMAN--ETC(U)
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where X_1 = dollars in PE 721111

d^- = the negative deviational variable

d^+ = the positive deviational variable

GOAL = the stated goal or objective for Line Items Shipped

In GP, the priority structure refers to the priorities placed on minimizing the deviational variables. It is common for the deviational variables for several different equations to have the same priority.

As was discussed in the main report, the study team grouped the GP goals into five categories:

(1) Totally allocate the P7S budget

(2) Assure minimum funding via "fence" option

(3) Maintain balanced relationships between PEs

(4) Meet stated workload

(5) Achieve numerical performance goals

The first goal category consists of a single equation which sums the values for X_i, and compares the sum to the total P7S budget for the PEs in this model. Since it is important to both (1) spend all of the monies allocated to P7S, and (2) not spend more than is allocated, this equation has both positive and negative deviational variables. Both d^- and d^+ are assigned Priority 1, which means this equation will be satisfied before any other conflicting equations. In essence, this means that d^- and d^+ will both be zero in the final output. This is Equation 1 in the priority structure file.

The second goal category consists of nine equations which set the minimum funding for each PE at zero dollars. Since the funding for each

PE is a problem only if it is negative, these equations have only negative deviational variables, d^-, which are assigned Priority 2. The positive deviational variables are not used since there is no reason to minimize the deviations above zero. The right hand side values for these GP equations are initialized at zero. If the model user chooses to fence any PE, the right hand side value for that PE's equation is changed from zero to the fenced value. These nine equations are represented as Equations 20 through 28 in the priority structure file.

The third goal category consists of the eighteen I-O equations in Tables C-5 and C-6. The nine equations in Table C-5 represent the major I-O equations, and are labeled as Equations 2 through 10 in the priority structure file. The nine equations in Table C-6 are additional I-O equations, and are labeled as Equations 11 through 19 in the priority structure file. These two subsets of linear equations do not necessarily have the same priorities for their deviational variables. These equations have, in general, negative deviational variables. The exceptions are those equations with F_3 and F_8 discussed previously.

The fourth and fifth categories consist of the six workload and seven performance equations in Table C-1. Since overachievement is not a problem with these goals, these equations have only negative deviational variables, d^-. These thirteen equations are represented as Equations 29 through 41 in the priority file structure.

The priority structure file is shown in Table C-7, which is a computer listing of one of the input files to the computer program

RECORD NUMBER	RECORD CONTENTS
1	41
2	20
3	5
4	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
5	8 8 8 8 8 8 8 8 8 8 8 8 8
6	NEG,1,1,1
7	POS,1,1,1
8	NEG,2,3,1
9	POS,2,3,1
10	NEG,3,3,1
11	POS,3,3,1
12	NEG,4,3,1
13	POS,4,3,1
14	NEG,5,3,1
15	POS,5,3,1
16	NEG,6,3,1
17	POS,6,3,1
18	NEG,7,3,1
19	POS,7,3,1
20	NEG,8,3,1
21	POS,8,3,1
22	NEG,9,3,1
23	POS,9,3,1
24	NEG,10,3,1
25	POS,10,3,1
26	NEG,11,5,1
27	NEG,12,5,1
28	POS,13,5,1
29	NEG,14,5,1
30	NEG,15,5,1
31	NEG,16,5,1
32	NEG,17,5,1
33	POS,18,5,1
34	NEG,19,5,1
35	NEG,20,2,1
36	NEG,21,2,1
37	NEG,22,2,1
38	NEG,23,2,1
39	NEG,24,2,1
40	NEG,25,2,1
41	NEG,26,2,1
42	NEG,27,2,1
43	NEG,28,2,1
44	NEG,29,4,4
45	NEG,30,4,1
46	NEG,31,4,2
47	NEG,32,4,1
48	NEG,33,4,47
49	NEG,34,4,32
50	NEG,35,4,56
51	POS,36,4,56
52	POS,37,4,56

Table C-7. Priority Structure Input File

RECORD NUMBER	RECORD CONTENTS
53	POS,38,4,56
54	NEG,39,4,56
55	POS,40,4,56
56	NEG,41,4,56
57	END,0,0,0
58	1,1,1
59	1,2,1
60	1,3,1
61	1,4,1
62	1,5,1
63	1,6,1
64	1,7,1
65	1,8,1
66	1,9,1
67	2,1,-.449083
68	2,2,.128925
69	2,3,.016069
70	2,6,.135584
71	2,7,.097725
72	2,10,1
73	3,1,.030663
74	3,2,-.158306
75	3,3,.100527
76	3,11,1
77	4,2,.165432
78	4,3,-.243296
79	4,6,.193248
80	4,12,1
81	4,13,-1
82	5,1,.068108
83	5,2,.068108
84	5,3,.068109
85	5,4,-.513666
86	5,5,.068106
87	5,7,.000357
88	5,8,.068111
89	5,9,.068109
90	5,14,1
91	6,1,.056980
92	6,2,.178712
93	6,3,.178709
94	6,4,.178713
95	6,5,-.731024
96	6,7,.000942
97	6,8,.178714
98	6,9,.178709
99	6,15,1
100	7,1,.016937
101	7,6,-1.0
102	7,16,1
103	8,1,.023374
104	8,7,-.994719

Table C-7. Priority Structure Input File (Cont'd)

RECORD NUMBER	RECORD CONTENTS
105	8,17,1
106	9,3,.083773
107	9,8,-.075461
108	9,18,1
109	9,19,-1
110	10,1,.027729
111	10,2,.027730
112	10,3,.551404
113	10,4,.027732
114	10,5,.027734
115	10,7,.000143
116	10,8,.027731
117	10,9,-.700233
118	10,20,1
119	11,10,1
120	12,11,1
121	13,12,-1
122	13,13,1
123	14,14,1
124	15,15,1
125	16,16,1
126	17,17,1
127	18,18,-1
128	18,19,1
129	19,20,1
130	20,1,1
131	21,2,1
132	22,3,1
133	23,4,1
134	24,5,1
135	25,6,1
136	26,7,1
137	27,8,1
138	28,9,1
139	29,1,.01081
140	29,2,.01081
141	29,3,.01081
142	30,1,.01939
143	30,2,.01939
144	31,2,.03152
145	31,3,.03152
146	32,1,.03269
147	33,1,.00058403
148	33,3,.00058403
149	34,1,.0010542
150	34,3,.0010542
151	35,2,.00170
152	36,1,.00037248
153	37,1,.00029074
154	38,1,.00050722
155	39,1,.00038271
156	40,1,.000062653

Table C-7. Priority Structure Input File (Cont'd)

RECORD NUMBER	RECORD CONTENTS
157	41,1,.000086127
158	41,2,.000086127
159	41,3,.000086127
160	41,4,.000086127
161	41,5,.000086127
162	41,7,.000086127
163	41,8,.000086127
164	41,9,.000086127
165	0,0,0
166	1177020
167	0
168	0
169	0
170	0
171	0
172	0
173	0
174	0
175	0
176	96084.5159
177	3734.631218
178	4578.596576
179	21313.36721
180	21532.32872
181	46066.77412
182	52386.30023
183	5847.250075
184	2380.61988
185	0
186	0
187	0
188	0
189	0
190	0
191	0
192	0
193	0
194	6189.203
195	8677.029
196	9261.43
197	9420.41
198	245.93
199	461.74
200	260.9
201	98.2
202	79.8
203	137.3
204	113.0
205	15.71
206	111.0

Table C-7. Priority Structure Input File (Cont'd)

discussed in Annex I. Record 1 in this file is the number of equations in the GP. Record 2 is the number of decision variables, X_i. In this model, the additional decision variables are for the F_i discussed earlier. Record 3 is the number of priority levels. Records 4 and 5 represent the "sign" of the equations. In this case the "B" implies deviations in both directions are possible (although we may wish to minimize some of these deviations).

Records 6 through 57 contain information on the deviational variables. Consider Record 9. The "POS" implies a positive deviational variable (d^+); the "2" refers to the equation number; the "3" refers to the priority assigned to that deviational variable; and the "1" refers to the weight assigned to that deviational variable. The "END, 0,0,0" in Record 57 implies that this is the end of the deviational variable information.

Records 58 through 165 contain information on the coefficients for the various equations. For example, consider Record 67. The "2" refers to the equation number (in this case, the equation at the top of Table C-5); the "1" refers to the variable number (in this case, the coefficient of X_1), and the "-.449083" is the coefficient. The "0,0,0" in Record 165 implies the end of the equation coefficients.

Records 166 through 206 represent the right-hand side values for Equations 1 through 41, respectively. Note that the right hand side values for the workload and performance equations (Records 194 through 206) are obtained by transposing the intercept constants of the equations in

Table C-1 and combining this value with the GOAL for that equation. For example, the intercept for the first equation in Table C-1 is -4938.1 (Actions Initiated), and the GOAL is 1251.103. Thus, the right hand side value is:

$$1251.103 - (-4938.1) = 6189.203$$

This value is shown in Record 194.

The computer program requires a second data input file. This file, shown in Table C-8, contains budget and goal information. Specifically, Record 1 is the year basis for the dollars. In this case, the dollars are in FY 79 dollars, and must be converted by the computer program to FY 78 constant dollars to be compatible with the equations. Records 2 through 12 contain the direct, funded reimbursable, and automatic reimbursable obligations for the PEs represented in this model. Note that the PEs that are normally combined; e.g., PE 722829 and PE 722898, are separate here. The order of the PEs is the same order as shown in Figure 4 of the main report.

Records 13 through 25 are the numerical workload and performance goals for the equations in Table C-1. The workload goals are taken from the COBE, and the performance goals are taken from the Commander's Handbook for Performance Indicators.

As discussed in the main report, the model output comes in three pages. These are shown in Figures 4, 5, and 6 of the main report, and will not be discussed further here. However, one should be able to see certain parallels between the data in Table C-8 and Model Output Pages 1 and 3.

RECORD NUMBER	RECORD CONTENTS		
1	79		
2	255784	21042	2034
3	117732	216	38800
4	107190	100	23938
5	69105	0	3412
6	87766	0	4713
7	181080	1000	37286
8	65500	0	0
9	44733	0	0
10	77982	0	438
11	108625	1454	38726
12	388	0	0
13	1251.103		
14	3953.329		
15	3046.35		
16	5646.91		
17	119.43		
18	171.84		
19	89.0		
20	89.0		
21	90.0		
22	85.0		
23	83.0		
24	98.0		
25	85.0		

Table C-8. Budget and Goal Input File

It is important to note that the model output in the main report was obtained using the input files in Tables C-7 and C-8. The priority structure (Table C-7) could and should be changed to investigate the effects of alternate priority structures. In practice, this file is accessed interactively external to the goal program through the use of the EDITOR or other computer file manipulation routines.

ANNEX D

DESCRIPTION OF PROGRAM ELEMENTS

ANNEX D

DESCRIPTION OF SUPPLY PROGRAM ELEMENTS

The Army Management Structure (AMS) is the official budgeting framework for the Army. The AMS is described in detail in AR-37-100-XX, where the "XX" refers to the applicable fiscal year. Since FY 78 was used as a base for the model, AR-37-100-78 was the basic reference for the program elements in this study. The PEs applicable to this study are briefly described in the remainder of this annex. Note that PE 728009, First Destination Transportation, is included in this list even though it is not in AR-37-100-78. This PE was first established in FY 79, and it was included in the model to make it compatible with future budgets.

a. PE 721111, Supply Depot Operations, provides for internal operations at Army depots and arsenals. It includes the receipt of materiel into depots, care of supplies in storage (COSIS), the issue and shipment of assigned stocks and all operations incident thereto. It also includes stock control activities (processing of receipt documents, maintaining order files, receiving, recording, and processing material request documents and maintaining requisition files) when performed in depots and administrative portions of traffic management performed within depots.

b. PE 721112, Supply Management Operations, provides for the operation of Inventory Control Points and other activities performing supply management functions. It includes inventory management, provisioning, requirements computations for all principal and secondary items, and directions initiated resulting from requirements computations; e.g., cataloging, procurement, redistribution, rebuild, and disposal. It also includes the

control and processing of receipt documents and maintaining active and complete order files; receiving, recording, and processing material request documents; maintaining requisition files and providing status information on requisitions and maintaining stock records.

c. PE 721113, Central Procurement Activities, includes operation of the Army's Central procurement offices and provides for contract administration and quality assurance not assigned to the Defense Contract Administration Service. Specifically, it provides for the actions following the receipt of a procurement request including the preparation and issuance of solicitations, evaluation of bids and proposals, and negotiation and award of contractual documents; overall management of the procurement function including policy formulation; planning actions designed to assure that purchase requirements are fulfilled; and quality assurance actions in support of Central Procurement Offices.

d. PE 722829, Logistics Administrative Support, includes the costs of Central Supply Activities performed by system/program/project/product managers and the cost of dispersed activities performing logistics control and direction functions in support of Central Supply Activities.

e. PE 722896.Z, Base Operations, Central Supply Activities, provides for those activities of an installation support nature. It includes those support elements and services identified as indirect overhead by Headquarters, Department of the Army. It includes audio-visual services, supply operations, maintenance of materiel, transportation services, laundry and drycleaning services, the Army Food Service program, personnel support,

bachelor housing furnishings support, operation of utilities, maintenance and repair of real property, minor construction, other engineering support, administration, data processing activities, and installation restoration.

f. PE 722898, Management Headquarters, provides for the operations of HQ DARCOM, HQ Staff Support Activities, and mid-management commodity commands under HQ DARCOM.

g. PE 728009, First Destination Transportation, includes the movement of Army supplies and equipment directly from the vendor to either a CONUS depot, a CONUS user unit, or a CONUS port for shipment to an overseas user.

h. PE 728010, Second Destination Transportation, includes movement of Army supplies and equipment worldwide, after receipt from production at either CONUS port, CONUS depot, or CONUS customer; and Army Industrial Fund (AIF) water port operations.

i. PE 728011, Industrial Preparedness Operations, provides for those operations which are performed to assure the production capability required to support current and emergency procurement programs, including actions taken by the Department of Defense to augment the production capability of the industrial base.

j. PE 728012, Logistics Support Activities, provides for central supply logistics activities including: attendant central supply services; production engineering, Defense Standardization Program, facilities investigation and studies, and DARCOM mission support activities. It also includes the preparation for and disposal of excess, surplus, and foreign

excess property. This includes the demilitarization of combat materiel and other military supplies and equipment for the Property Disposal Activities.

k. PE 728013, Overseas Port Units (Non-IF), provides for the non-industrially funded overseas water ports pertaining to the receipt and shipment of cargo and passengers.

ANNEX E

DATA

ANNEX E

DATA

This annex contains the raw data used in the DELTA 7S Study. These data were arranged in a master data file, and were indexed by a unique three digit number. These numbers are shown in Table E-1, and the master data file is shown in Table E-2. The only transformation to these data was inflation of the resource data to constant FY 78 dollars using inflation guidance published by HQ DARCOM. The inflation indicies are shown in Table E-3.

Variable Number	Name
501	Dollars in 721111
502	Dollars in 721112
503	Dollars in 721113
504	Dollars in 722829/98
505	Dollars in 722896.Z
506	Dollars in 728010/13
507	Dollars in 728011
508	Dollars in 728012
509	Dollars in 721111 + 721112
510	Dollars in 721112 + 721113
511	Dollars in 721111 + 721112 + 721113
512	Dollars in 728011 + 728012
513	Dollars in 722829/98 + 722896.Z
514	Dollars in 722829/98 + 722896.Z + 728012
515	Dollars in ΣXi $i = 1,9$ except X_6 (728009)
516	Dollars in ΣXi less 721111, 721112, and 721113
517	Dollars in 721111 + 721113
601	Line Items Managed
602	Supply Studies
603	Commodity Management Actions/No. Actions Initiated
604	Requisitions Processed - Total
605	Requisitions Processed - ADP
606	Requisitions Processed - Manual

Table E-1. Variables in Master Data File

Variable Number	Name
607	Requisitions Received
608	Line Items Received
609	Tons Received
610	Line Items Shipped
611	Tons Shipped
612	Procurement Actions
613	Backlog
614	Total Procurement (612 + 613)
615	FSN in Stock
616	Tons Received and Shipped (609 + 611)
701	DARCOM Stock Availability Rate
702	DARCOM Stock Availability Rate - NORS
703	DARCOM Backorders Outstanding
704	DARCOM Backorders Outstanding - NORS
705	Percent Backorders over 90 Days
706	Percent Backorders over 90 Days - NORS
707	DARCOM On-Time Requisition Processing
708	DARCOM On-Time Requisition Processing - NORS
709	NICP On-Time Requisition Processing
710	NICP On-Time Requisition Processing - NORS
711	Depot On-Time Requisition Processing
712	Depot On-Time Requisition Processing - NORS

Table E-1. Variables in Master Data File (Cont'd)

Variable Number	Name
713	DARCOM On-Time Transportation Rate
714	DARCOM On-Time Receiving Rate - Reporting
715	DARCOM On-Time Receiving Rate - Stowing
716	DARCOM Materiel Release Denial Rate
717	DARCOM Location Survey Accuracy

Table E-1. Variables in Master Data File (Cont'd)

Variable Number	FY74	FY75	FY76	FY77	FY78
501	252565.	254507.	271912.	296812.	290168.
502	154573.	155122.	154161.	157233.	146954.
503	125043.	120320.	121003.	123387.	122386.
504	211123.	152713.	223521.	231639.	152199.
505	160733.	160374.	165265.	169713.	242050.
506	50342.1	47682.4	46059.0	48212.1	41012.0
507	52053.5	53766.9	55784.8	62247.8	69503.0
508	155479.	168247.	183898.	167436.	134066.
509	407144.	411629.	426073.	454050.	437122.
510	279622.	273442.	275164.	280625.	259340.
511	532187.	531949.	547076.	577437.	559508.
512	207533.	222014.	239683.	229684.	203569.
513	371861.	343087.	388786.	401352.	404249.
514	527340.	511334.	572684.	568788.	538315.
515	.116192E+07	.114473E+07	.122160E+07	.125669E+07	.120834E+07
516	629736.1	612783.4	674528.0	679248.1	648830.0
517	377608.0	378827.0	392827.0	420199.0	412554.0
601	522.000	654.000	660.000	602.460	1161.12
602	610.000	555.000	590.000	768.000	758.000
603	838.740	821.290	814.930	1249.86	1278.88
604	3182.01	3198.14	3552.47	4025.54	3830.47
605	2325.56	2273.51	2664.05	3215.05	3183.91
606	856.450	924.630	888.420	810.490	646.560
607	2700.00	2756.00	2909.00	3240.00	3450.00
608	2169.47	2288.46	2199.35	2207.65	1938.63
609	1204.40	1215.47	1251.10	1397.51	1046.39
610	4525.22	4714.50	4935.44	5847.80	5896.17
611	1308.33	1249.00	1134.50	1325.94	1231.87
612	95.4100	97.6100	94.8800	114.230	124.340
613	14.6500	14.1200	17.2900	27.6600	39.1200
614	110.060	111.730	112.170	141.890	163.460
615	253.010	198.740	244.130	259.950	349.150
616	2512.73	2464.47	2385.60	2723.45	2278.26
701	70.0000	75.0000	81.7500	81.0000	77.2500
702	71.0000	75.0000	82.7500	82.0000	74.5000
703	216.000	178.000	144.000	192.000	270.000
704	7.00000	6.00000	6.00000	9.00000	17.3000
705	53.0000	45.0000	46.0000	46.0000	53.0000
706	28.0000	18.0000	20.0000	27.0000	33.0000
707	85.0000	86.0000	83.7500	85.0000	75.7500
708	69.0000	78.0000	79.5000	84.5000	83.2500
709	90.0000	92.0000	88.5000	92.7500	75.7500
710	90.0000	80.0000	89.2500	80.2500	92.0000
711	93.0000	92.0000	85.7500	62.2500	72.0000
712	94.0000	94.0000	91.5000	87.0000	80.2500
713	61.0000	72.0000	78.5000	60.7500	81.0000
714	94.0000	98.0000	90.7500	86.0000	82.0000
715	91.0000	95.0000	82.7500	74.7500	71.0000
716	1.50000	1.30000	1.30000	1.65000	1.40000
717	97.4000	98.3000	96.4000	95.4000	95.2000

Table E-2. Master Data File

INFLATION FACTORS (FY 78 BASE)*

FY	1974	1975	1976	1977	1978	1979	1980	1981
	.79935	.84180	.88517	.92678	1.000	1.06497	1.1342	1.20222

*Based on a projection from a FY 77 Base

SOURCES: Letter, DRCCP-BF, 14 Sep 76, subject: FY 77 Command Analysis of OMA Funding Inflation Indicies
Letter, DRCCP-ER, 28 Dec 77, Subject: Inflation Guidance

Table E-3. Inflation Factors

ANNEX F

SENSITIVITY ANALYSIS

ANNEX F

SENSITIVITY ANALYSIS

The study team did not perform a formal sensitivity analysis in the sense that each variable was investigated over a range of values to determine its optimum value. However, the study team did investigate the sensitivity of the model output to the priority structure. Table F-1 shows the model output for four different priority structures. Note that this table excludes PE 728009. Although this analysis was performed prior to the addition of this PE, the general results are still applicable. The Roman numeral column headings refer to the four different priority structures at the bottom. The "Spend Budget" priority is the sum of all the variables equation. The "Balance" priority is the first series of I-O equations derived. The "Output Level" priority is the second series of I-O equations derived which determines the F_i values. The "workload" priority is the series of workload equations. Performance equations and the fence provision were not included in this analysis.

Note that the workload and balance equations are conflicting. Priority Structure I places the workload at the lowest priority, and the model allocation is essentially the same as the COBE. However, as the workload is placed at a priority higher than the balance equations (Priority Structure III), the model allocations for PE 721111, PE 721112, and PE 721113 (the "hard" accounts) are considerably higher than are the COBE allocations. The extra funds for these PEs come from the "soft" accounts such as PE 728011. As noted previously, the descriptors "hard" and "soft" are not intended to be derogatory, but refer to the degree to which the impact of fund changes can be quantified.

This sensitivity is not bad per se. The model does what it is told to do via the priority structure. The solution is that the model user must become very familiar with the model operation and priority structure changes.

MODEL ALLOCATIONS

PE	'79 COBE ESTIMATE	I	II	III	IV
721111	261,748	261,645	289,951	289,204	261,692
721112	154,540	153,925	167,439	167,098	154,328
721113	126,374	125,994	138,112	137,803	125,837
722829/98	164,579	167,569	167,569	167,569	167,569
722896.Z	208,369	208,374	204,585	204,685	208,367
728010/13	58,815	58,815	58,815	58,815	58,815
728011	62,807	64,177	5,308	6,828	64,003
728012	136,788	136,512	145,230	145,007	136,399
PRIORITIES:					
SPEND BUDGET		1	1	1	1
BALANCE		2	2	3	2
OUTPUT LEVEL		3	4	4	3
WORKLOAD		4	3	2	3

Table F-1. Model Sensitivity

ANNEX G

VALIDATION

ANNEX G

VALIDATION

The regression equations for workload and performance described in Annex C were initially developed using four data points: FY 74 through FY 77. The equations chosen were based on mathematical fit and functional logic. A 90 percent prediction interval was determined for each equation. Then the observed value for FY 78 (which was not included in the equation calculations) was compared to the prediction interval limits. When the observed value fell within these limits, the data base was augmented to include the FY 78 data. The equation coefficients were then reevaluated based upon five data points. In those instances where the observed FY 78 data fell outside the prediction interval, the equation was scrapped, and new equations were developed based again upon four data points (FY 74 to FY 77). The above validation procedure was repeated until the FY 78 observed data fell within the prediction interval. The equations in Table C-1 were all validated using this procedure.

The validation of the input-output equations was less formal. The I-O budget allocation table was first based on information from the FY 78 COBE. When the FY 79 COBE became available, the study team reevaluated the transfer coefficients (A matrix) based on the new data. When compared, the two different sets of I-O coefficients were consistent. This procedure was discussed in Reference 2-g of the Literature Survey (Annex B) as a method of validation.

The validation of the goal programming model was even less formal. Although the algorithm itself was checked against "textbook" examples, no attempt was made to solve the DELTA 7S goal program by hand. However,

during one of the study briefings, new budget information was made available. When this new information was reallocated by the model during the briefing, the results were very similar to those obtained by the Budget personnel working manually over the prior three-week period.

ANNEX H

USER INSTRUCTIONS

ANNEX H

USER INSTRUCTIONS

This annex contains the detail instructions that enable a user to access and apply the DELTA 7S model. These instructions are divided into three sections:

Section A Procedures for Operation of the DELTA 7S Model

Section B Description of the Input Files

Section C File Operations

These instructions are written based upon the timesharing use of the Picatinny Arsenal computer. Although the program is written in FORTRAN and should be executable on any computer with a FORTRAN capability, the user instruction will change for different computers.

Section A: PROCEDURE FOR OPERATION OF DELTA 7S MODEL

1. Prepare local equipment

a. Turn on Tektronix 4051, page printer and telephone modem.

b. To allow the Tektronix 4051 to operate as an interactive terminal, enter the following:

```
CALL "MARGIN",1,Ø,Ø    [RETURN]
CALL "TERMIN"          [RETURN]
```

2. Access the computer at Picatinny Arsenal

a. Using the phone in the "CALL" mode, dial 9-201-328-4047.

b. When high-pitched tone is heard, press "DATA" button on phone and place receiver in cradle.

3. LOGIN Procedure

a. After Step 2 is completed, computer responds:

```
CONTROL DATA INTERCOM 4.5
DATE .........
TIME .........
```

b. Enter:

LOGIN, (as assigned)

c. Computer responds:

XXXXXXXX   ENTER PASSWORD

d. Enter:

(as assigned)

e. Computer responds:

```
date   LOGGED IN AT time
       WITH USER-ID _ _
       EQUIP/PORT _ _ 7 _ _ _
COMMAND--
```

f. Enter:

ETL,400

g. Computer responds:

COMMAND--

h. Enter:

FETCH, ALLOC

i. Computer responds:

ID=

j. Enter:

KLOPP

k. Computer responds:

COMMAND--

--Push Home Page

l. Enter:

ALLOC

m. At this point the computer begins to execute the program to allocate the 7S budget.

4. Designation of Input Files:

a. In order to function, the program must know the names of the file containing the priority structure (and input coefficients) and the file containing the budget allocation against which the model allocation is to be compared. A description of the files initially available in the account is given in Annex B. The computer will prompt the user for the appropriate file names.

b. Computer responds:

ENTER BUDGET FILE NAME

c. Enter:

filename *Can be name of any file containing budget allocation (COBE4, for example)

d. Computer responds:

ENTER PRIORITY STRUCTURE FILENAME

e. Enter:

filename *Can be name of any file containing priority structure (PRIOR1, for example)

5. Execution of Model Computations:

a. Prior to performing any computations, the model displays the present budget (as listed in the file designated in 4c above) and affords the user the opportunity to "fence" any PE values or to change the total funds available. An example of this, where PE 728009 has been "fenced" at $65500 and the total budget has been left unchanged ($1289044), is shown below:

	PROG ELEM	DIRECT	REIMBURSABLE FUNDED	REIMBURSABLE AUTOMATIC	TOTAL
1	721111	255784.	21042.	2034.	278860.
2	721112	117732.	216.	38800.	156748.
3	721113	107190.	100.	23938.	131228.
4	722829	69105.	0.	3412.	72517.
5	722898	87766.	0.	4713.	92479.
6	722896.Z	181080.	1000.	37286.	219366.
7	728009	65500.	0.	0.	65500.
8	728010	44733.	0.	0.	44733.
9	728011	77982.	0.	438.	78420.
10	728012	108625.	1454.	38726.	148805.
11	728013	388.	0.	0.	388.
	TOTALS	1115885.	23812.	149347.	1289044.

```
IF YOU WISH TO 'FENCE' A PE VALUE, ENTER ITS ROW
NUMBER AND THE DOLLAR VALUE(IN THOUSANDS) SEPARATED
BY A COMMA. WHEN NO FURTHER 'FENCING' IS DESIRED,
ENTER 0,0  7,65500

ENTER NEXT 'FENCE' OR 0,0  0,0

ENTER THE TOTAL FUNDS AVAILABLE (IF THIS IS
TO BE THE SAME AS THE TOTAL ABOVE, ENTER 0 )  0
```

b. Computer responds:

END OF PAGE 1

c. The computer has now suspended computations to allow the user to make a page copy of what is displayed on the screen. If you desire a pagy copy, simply press the "MAKE COPY" key on the Tektronix 4051 and the screen display will be reproduced at the printer. Push "Home Page." To release the computer to resume computations, enter a 0.

d. The computer will make an "optimal" allocation of the total 7S budget in accordance with the priorities established in the file designated in 4e above. An example of the output is shown below:

	DIRECT		TOTAL	
PROG ELEM	COBE	MODEL	COBE	MODEL
721111	255784.0	269643.4	278860.0	292719.4
721112	117732.0	104973.9	156748.0	143989.9
721113	107190.0	107076.7	131228.0	131114.7
722829/98	156871.0	164819.6	164996.0	172944.6
722896.Z	181080.0	174934.1	219366.0	213220.1
728009	65500.0	65500.0	65500.0	65500.0
728010/13	45121.0	59542.7	45121.0	59542.7
728011	77982.0	67631.9	78420.0	68069.9
728012	108625.0	101761.4	148805.0	141941.4
	---------	---------	---------	---------
	1115885.0	1115883.8	1289044.0	1289043.0

END OF PAGE 2

e. The "END OF PAGE 2" is again an indication that the computer has paused to allow the display to be copied. A copy is made as before; push "Home Page;" enter a 0 to continue.

f. The computer will next display the goals and predicted levels of achievement for selected workload and performance indicators. These predictions (PRED) are displayed for both the budget allocation designated in 4c above and for the allocation computed by the model. The difference columns (DIFF) give the difference between the respective predictions and the goal. A positive difference indicates over-achievement; a negative difference indicates under-achievement. An example of this portion of the output is shown below.

PARAMETER		GOAL	TOPE PRED	TOPE DIFF	MODEL PRED	MODEL DIFF
NO. ACTIONS INITIATED	(K)	1251.1	1189.4	-61.7	1334.4	83.3
REQN. PROCESSED TOTAL	(K)	3953.3	3722.7	-230.6	4017.8	64.5
TONS RECEIVED & SHPD	(K)	3046.4	2861.9	-184.4	2857.7	-188.6
LINE ITEMS SHIPPED	(K)	5646.9	5342.4	-304.5	5786.0	139.1
PROCUREMENT ACTIONS	(K)	119.4	113.0	-6.4	119.9	.4
TOTAL PROC(PA+BACKLOG)	(K)	171.8	142.4	-29.4	154.8	-17.0
NICP OT REQN. PROC.	(%)	89.0	94.6	5.6	97.4	8.4
DEPOT OT REQN. PROC.	(%)	89.0	83.3	-5.7	76.9	-12.1
DARCOM REC. RATE-REPT.	(%)	90.0	88.7	-1.3	83.7	-6.3
DARCOM OT REC.-STOW.	(%)	85.0	80.9	-4.1	74.0	-11.0
DARCOM OT TRANS. RATE	(%)	83.0	76.7	-6.3	83.3	.3
LOCATION SURVEY ACC.	(%)	98.0	96.2	-1.8	95.5	-2.5
STOCK AVAIL. RATE	(%)	85.0	79.4	-5.6	79.3	-5.7

END OF PAGE 3
IF YOU WANT TO MAKE FURTHER CHANGES, ENTER A 1
ANY OTHER ENTRY WILL TERMINATE THE PROGRAM.

g. Entry of a "1" at this point will cause the model to cycle back to the start of the computational phase (paragraph 5 above). The user will again have the opportunity to "fence" PE values or change the budget. The same priority structure and budget files that were designated in paragraph 4 above will be used again. As before, a page copy of the display can be made while the computer awaits a response.

h. If an entry other than "1" is made, the computer responds:

END OF PROGRAM

COMMAND--

6. Session Termination

a. To terminate the session, simply enter LOGOUT after the computer has prompted COMMAND--.

b. The computer will display the time and cost data for the session. Turn off all equipment before leaving.

Section B: DESCRIPTION OF INPUT FILES

1. Budget File

a. The budget file contains a budget allocation against which the allocation of the model is to be compared. The information in this file is printed as page one of the model output. It is not necessary to sum the rows or columns; this is done automatically and displayed on page one of the output.

b. Row 1 of the budget file contains a two-digit number indicating the dollar-year in which the budget allocation is expressed. For example, the budget file COBE4 is in FY 79 dollars; Row 1 of COBE 4, as shown in subparagraph f below, contains the number 79.

c. Rows 2 through 12 of the budget file correspond to the following 11 program elements, respectively:

ROW #	PE
2	721111
3	721112
4	721113
5	722829
6	722898
7	722896.Z
8	728009
9	728010
10	728011
11	728012
12	728013

d. Each of the above 11 rows contains three dollar values (in thousands) for the direct, funded reimbursable and automatic reimbursable funds allocated to the corresponding program element. There must be at least one blank space between the values in each row.

e. Rows 13 through 25 contain the goals for selected workload and performance indicators which the model allocation attempts to achieve. This information, along with the predicted achievement of both the model allocation and the allocation specified in Rows 2 through 12, appears on page 3 of the output. The values entered in Rows 13 through 25 correspond to the goals established for the following workload/ performance indicators:

ROW #	WORKLOAD/PERFORMANCE INDICATOR
13	No. Actions initiated (K)
14	Reqn. Processed Total (K)
15	Tons Received & Shpd (K)
16	Line Items Shipped (K)
17	Procurement Actions (K)
18	Total Proc (PE + Backlog) (K)
19	NICP OT Reqn. Proc. (%)
20	Depot OT Reqn. Proc. (%)
21	DARCOM Rec. Rate-Rept. (%)
22	DARCOM OT Rec.-Stow. (%)
23	DARCOM OT. Trans. Rate (%)
24	Location Survey Acc. (%)
25	Stock Avail. Rate (%)

f. A budget file reflecting the FY 79 PBG (as of 16 Jan 79) has been established and given the file name "COBE4." It is listed below.

1	79		
2	255734	21042	2034
3	117732	216	38800
4	107190	100	23938
5	69105	0	3412
6	87766	0	4713
7	131080	1000	37286
8	65500	0	0
9	44733	0	0
10	77982	0	438
11	108625	1454	38726
12	388	0	0
13	1251.103		
14	3953.329		
15	3046.35		
16	5646.91		
17	119.43		
18	171.84		
19	89.0		
20	89.0		
21	90.0		
22	85.0		
23	93.0		
24	[illegible]		
25	[illegible]		

g. In order for the computer to be able to properly access the information in a budget file, the file must be in the format specified above. Instructions for creating a new file are given in Annex C.

2. Priority Structure File

a. The priority structure files contain the model representation of the priorities which govern the model's allocation of the budget, plus the coefficients for the balance and regression relationships. Although the priority structure files are easily modified to reflect a different set of priorities, to do so properly requires knowledge of the model format and goal programming. Therefore, the modification process will not be explained here. The remainder of this section will describe the priority structures of the files that have already been established and are available for use.

b. The model has been developed to achieve goals in the areas of total allocation of the 7S budget, complying with "fences" established in designated program elements, a "balanced" allocation among program elements and workload/performance objectives. For purposes of establishing a priority structure the balance goals have been divided into two sub-categories designated Balance 1 and Balance 2.

c. The priority structures represented by the files that are initially available in the account are shown in the table below. The number within the body of the table is the priority associated with the corresponding goal (row) within the corresponding file (column). Priorities are assigned in descending order, with 1 being the highest priority, 2 the next most important, etc.

		PRIORITY STRUCTURE FILES			
		PRIOR1	PRIOR2	PRIOR3	PRIOR4
	Total Allocation	1	1	1	1
	"Fences"	2	2	2	2
GOAL	Balance 1	3	3	4	3
	Balance 2	4	4	5	4
	Workload/Performance	5	4	3	4

Section C: FILE OPERATIONS

1. Creating a new budget file

a. A new budget file may be created at any time after LOGIN (Annex A) when the computer has displayed

COMMAND--

b. Enter:

EDITOR

c. Computer responds:

. .

d. Enter:

CREATE,1,1

e. Computer responds

1 =

f. Enter the desired information for the budget allocation in the format specified in Annex B. After each line is entered, the computer will respond with the next line number. After the final line has been entered (Line 25), the computer responds

26 =

g. Enter:

=

h. Computer responds

. .

i. Enter:

LIST,ALL

This command will provide a listing of the new file. A page copy may be made as in paragraph 5c, Annex A. After the listing, the computer again displays a double period (. .). If the file is correct, skip to subparagraph p below. If the file is incorrect, you must delete then re-enter the faulty line(s).

j. Enter:

DELETE, line number

k. Computer responds:

. .

l. Enter:

ADD, line number

m. Computer responds:

line number =

n. Enter:

correct data

o. Computer responds:

p. Enter: SAVE, filename*,N

*Can be any not previously designated file name. File name must not exceed 7 letters or digits, and the first character must be a letter.

q. Computer responds:

. .

r. Enter:

CATALOG,filename,filename,ID=KLOPP,CY=1

s. Computer responds:

```
INITIAL CATALOG
RP = 060 DAYS
CT ID = KLOPP PFN = filename
CT CY = 001     ________ WORDS.:
. .
```

t. Enter:

```
BYE
```

u. Computer responds

```
COMMAND--
```

2. Listing an existing file

a. An existing file may be listed at any time after LOGIN (Annex A) when the computer has displayed

```
COMMAND--
```

b. Enter

```
EDITOR
```

c. Computer responds:

```
. .
```

d. Enter:

```
FETCH filename
```

e. Computer responds:

```
ID =
```

f. Enter:

```
KLOPP
```

g. Computer responds:

```
. .
```

h. Enter:

EDIT,filename,S

i. Computer responds:

. .

j. Enter:

LIST,ALL

k. After listing is complete, computer responds:

. .

l. Enter:

BYE

m. Computer responds:

COMMAND--

TO DETERMINE WHAT IS IN THE ACCOUNT:

Computer	COMMAND--
User	ATTACH, X, SELECT AUDIT
Computer	COMMAND--
User	X
Computer	ID=
User	KLOPP
Computer	[Computer will list the files]
User	END or EXIT

ANNEX I

COMPUTER PROGRAM

ANNEX I

COMPUTER PROGRAM

The remainder of this annex contains the documented computer program for the DELTA 7S model. This FORTRAN program is based upon modifications to the program listed in Goal Programming for Decision Analysis by Sang M. Lee, and another modification to this program by the US Army Concepts Analysis Agency. This particular listing is operational on the HP 3000 minicomputer at the US Army Logistics Management Center. The program operational on the Picatinny Arsenal computer is essentially identical to this one.

```
$CONTROL NOLIST
$CONTROL USLINIT
$CONTROL FILE=1,FILE=2
C***********************************************************************
C                                                                      *
C                                                                      *
C                                                                      *
C                   *                ********** ********               *
C                  ***               **********  *********             *
C                ** **                         **   **                 *
C               **    **                      **    **                 *
C              **      **      ***         **     ********             *
C             **        **     ***        **       ********            *
C            **          **             **               **            *
C           **            **           **                **            *
C          *****************          **          *********            *
C         *******************        **           ********             *
C                                                                      *
C                                                                      *
C  GENERAL                                                             *
C     THE DELTA-7S PROGRAM IS A RESOURCE ALLOCATION MODEL DESIGNED     *
C     TO PROVIDE AN "OPTIMAL" ALLOCATION OF CHANGES IN THE 7S          *
C     PORTION OF THE DARCOM BUDGET.  IT WAS DEVELOPED AS PART OF A     *
C     STUDY ENTITLED "IMPACT OF INCREMENTAL CHANGES IN 7S FUNDING      *
C     ON SUPPLY PERFORMANCE" COMMISSIONED BY MG R. L. BERGQUIST,       *
C     OCGRM, DARCOM.  THE PROGRAM IS INTERACTIVE AND GIVES THE USER    *
C     THE OPPORTUNITY TO REVIEW A PARTICULAR BUDGET ALLOCATION,        *
C     "FENCE", OR CONSTRAIN, SELECTED PROGRAM ELEMENTS, THEN ENTER     *
C     THE NEW 7S BUDGET TOTAL.  A GOAL PROGRAMMING ALGORITHM,          *
C     ADAPTED FROM "GOAL PROGRAMMING FOR DECISION ANALYSIS," BY        *
C     SANG M. LEE,AUERBACH PUBLISHERS INC, 1972, IS USED TO ALLOCATE*
C     THE NEW BUDGET.  THE NEW ALLOCATION IS THEN DISPLAYED OPPOSITE*
C     THE EXISTING BUDGET ALLOCATION FOR COMPARISON.  FINALLY, EACH *
C     OF THESE ALLOCATIONS IS INPUT TO A SERIES OF WORKLOAD AND        *
C     PERFORMANCE EQUATIONS AND THE RESULTING PREDICTIONS ARE          *
C     DISPLAYED.  A COMPLETE DESCRIPTION OF THE DEVELOPMENT OF THE     *
C     MODEL COEFFICIENTS, INPUT DATA FILES AND REGRESSION(WORKLOAD/ *
C     PERFORMANCE) EQUATIONS IS CONTAINED IN THE FINAL STUDY REPORT.*
C                                                                      *
C***********************************************************************
C                                                                      *
C  MAIN PROGRAM                                                        *
C     THE MAIN PROGRAM PERFORMS THE ITERATIVE PROCESS FOR THE GOAL     *
C     PROGRAMMING MODEL.  INPUT DATA READ IN SUBROUTINE START IS       *
C     DEVELOPED INTO THE INITIAL TABLEAU.  AN EXISTING BUDGET          *
C     FILE(FILE=2) IS THEN READ AND DISPLAYED, WITH THE USER HAVING *
C     THE OPPORTUNITY TO "FENCE" SELECTED PROGRAM ELEMENTS AND/OR      *
C     CHANGE THE TOTAL AVAILABLE BUDGET.  THE MAIN PROGRAM THEN        *
C     ITERATES UNTIL THE OPTIMAL GOAL PROGRAMMING SOLUTION IS          *
C     REACHED.  SUBROUTINE FINAL IS THEN CALLED TO DISPLAY THE         *
C     OUTPUT.                                                          *
C                                                                      *
```

```
      C  VARIABLE DEFINITIONS IN THE MAIN PROGRAM                          *
      C     VARIABLE USAGE IN THE SUBROUTINES IS CONSISTENT WITH THE       *
      C     DEFINITIONS LISTED BELOW.  VARIABLE DEFINITIONS FOR THE        *
      C     SUBROUTINES WILL NOT REPEAT ANY OF THE BELOW LISTED            *
      C     DEFINITIONS.                                                   *
      C                                                                    *
      C     NROWS         NUMBER OF ROWS(GOALS OR CONSTRAINTS)             *
      C     NVAR          READ IN AS NUMBER OF DECISION VARIABLES.  UPDATED *
      C                   IN SUBROUTINE START TO INCLUDE DEVIATIONAL AND   *
      C                   ARTIFICIAL VARIABLES ADDED.                      *
      C     NPRT          NUMBER OF PRIORITY LEVELS.  SUBROUTINE START ADDS *
      C                   AN ADDITIONAL LEVEL TO ACCOMMODATE ARTIFICIAL    *
      C                   VARIABLES IF NECESSARY.                          *
      C     C(I,J)        TECHNOLOGICAL COEFFICIENTS OF THE SIMPLEX TABLEAU *
      C     RVLX(I,J)     ZJ-CJ VALUES FOR THE I TH PRIORITY, J TH VARIABLE *
      C     VALX(I,J)     CJ COEFFICIENTS FOR THE I TH PRIORITY, J TH VAR. *
      C     VALY(J,I)     CJ COEFFICIENTS FOR THE BASIS VARIABLES          *
      C     RHS(I)        RIGHT-HAND-SIDE VALUE FOR THE I TH ROW           *
      C     RHS1(I)       ORIGINAL RIGHT-HAND-SIDE VALUE FOR THE I TH ROW  *
      C     NWLPI         NUMBER OF WORKLOAD/PERFORMANCE INDICATOR EQUATIONS*
      C     INYR          DOLLAR YEAR OF EXISTING BUDGET FILE(FILE=2)      *
      C     FACTOR        INFLATION ADJUSTMENT FACTOR                      *
      C     COBE(I,J)     EXISTING BUDGET BY PROGRAM ELEMENT AND TYPE FUNDS *
      C     SUM(I)        ROW TOTAL OF BUDGET FILE, BY PROGRAM ELEMENT     *
      C     TOTAL(I)      COLUMN TOTAL OF BUDGET FILE, BY TYPE FUNDS       *
      C     BUDGET        TOTAL DOLLARS AVAILABLE IN EXISTING BUDGET FILE  *
      C     COBPRE(I)     PARTIAL PREDICTION  OF WORKLOAD/PERFORMANCE OF   *
      C                   EXISTING BUDGET.  COMPLETED IN SUBROUTINE FINAL  *
      C                   WHEN REGRESSION CONSTANT IS INCLUDED.            *
      C     FENCES(I,J) USER LIMIT PLACED ON INDIVIDUAL PROGRAM ELEMENTS   *
      C     X(J)          VARIABLE NUMBER OF VARIABLE IN THE J TH COLUMN   *
      C     Y(I)          VARIABLE NUMBER OF THE I TH VARIABLE IN THE BASIS *
      C     L1,K3         USED TOGETHER DURING ITERATIONS TO CHECK ARRAYS  *
      C                   STARTING AT LAST ROW, MOVING TO FIRST ROW        *
      C     SUMP          ZJ VALUE COMPUTED DURING SIMPLEX ITERATIONS      *
      C     ZMAX          MAXIMUM ZJ-CJ -> COEFFICIENT OF ENTERING VARIABLE *
      C     AMT(I)        RHS(I)/C(I,J) -> DETERMINES LEAVING VARIABLE     *
      C     ZMIN          MINIMUM AMT(I) -> LIMITING AMOUNT OF LEAVING VAR. *
      C     K2            COLUMN NUMBER TO ENTER BASIS                     *
      C     ITER          ITERATION NUMBER                                 *
      C                                                                    *
      C*********************************************************************
            DIMENSION C(41,102),RVLX(6,102),VALX(6,102),VALY
           *(41,5),RHS1(41),Y(41),RHS(41),AMT(41),COBPRE(13),
           *X(102),COBE(11,3),PE(11),SUM(11),TOTAL(3),FENCES(11,2)
            CHARACTER*9 PE
            DATA PE(1),PE(2),PE(3)/9H721111   ,9H721112   ,9H721113   /
            DATA PE(4),PE(6),PE(7)/9H722829   ,9H722896.Z ,9H728009   /
            DATA PE(8),PE(9),PE(10)/9H728010   ,9H728011   ,9H728012   /
            DATA PE(5),PE(11)/9H722898   ,9H728013   /
            NWLPI = 13
       9999 CALL START(NROWS,NVAR,NPRT,C,VALX,VALY,RHS,RVLX)
```

```
      C - - - - - - - - - - - - - - - - - - - -
      C  READ "DOLLAR YEAR" AND SET INFLATION -
      C  FACTOR.                                -
      C - - - - - - - - - - - - - - - - - - - -
            READ(201,*) INYR
            IF(INYR.EQ.78) FACTOR = 1.0
            IF(INYR.EQ.79) FACTOR = 1.06497
            IF(INYR.EQ.80) FACTOR = 1.1342
            IF(INYR.EQ.81) FACTOR = 1.20222
      C - - - - - - - - - - - - - - - - - - - -
      C  READ AND DISPLAY EXISTING BUDGET       -
      C  ALLOCATION(FILE=2).                    -
      C - - - - - - - - - - - - - - - - - - - -
            DO 100 I=1,11
            READ(20I+1,*)(COBE(I,J),J=1,3)
        100 SUM(I) = COBE(I,1)+COBE(I,2)+COBE(I,3)
            BUDGET =0
            DO 130 J=1,3
            TOTAL(J) = 0
            DO 120 I = 1,11
        120 TOTAL(J) = TOTAL(J)+COBE(I,J)
        130 BUDGET = BUDGET + TOTAL(J)
            WRITE(6,900)
        900 FORMAT(1H1,21X,6HDIRECT,14X,12HREIMBURSABLE,13X,5HTOTAL,/,
           *        1H ,2X,9HPROG ELEM,25X,6HFUNDED,7X,9HAUTOMATIC,'/)
            WRITE(6,901)(I,PE(I),(COBE(I,J),J=1,3),SUM(I),I=1,11)
        901 FORMAT(1H ,I2,2X,A9,8X,F7.0,8X,F7.0,8X,F7.0,7X,F8.0)
            WRITE(6,902)
        902 FORMAT(1H ,21X,7H_______,8X,7H_______,8X,7H_______,8X,7H_______)
            WRITE(6,903)(TOTAL(I),I=1,3),BUDGET
        903 FORMAT(1H ,4X,6HTOTALS,10X,F8.0,8X,F7.0,8X,F7.0,7X,F8.0,///)
      C - - - - - - - - - - - - - - - - - - - -
      C  CONDENSE 11 PROGRAM ELEMENTS DIS-      -
      C  PLAYED TO 9 USED IN MODEL.             -
      C - - - - - - - - - - - - - - - - - - - -
            SUM(4) = SUM(4) + SUM(5)
            SUM(5) = SUM(6)
            SUM(6) = SUM(7)
            SUM(7) = SUM(8) +SUM(11)
            SUM(8) = SUM(9)
            SUM(9) = SUM(10)
      C - - - - - - - - - - - - - - - - - - - -
      C  COMPUTE WORKLOAD/PERFORMANCE PRE-      -
      C  DICTIONS USING THE ORIGINAL MODEL      -
      C  COEFFICIENTS(C(I,J)) AND THE BUDGET    -
      C  JUST READ IN(FILE=2).                  -
      C - - - - - - - - - - - - - - - - - - - -
            DO 132 I=1,NWLPI
        132 COBPRE(I) = 0.0
            DO 133 I=1,NWLPI
            DO 133 K=1,9
        133 COBPRE(I) = COBPRE(I) + C(I+28,2*NROWS+K)*SUM(K)/FACTOR
```

```
C - - - - - - - - - - - - - - - - - - - - - - -
C  "FENCE" CHOSEN PROGRAM ELEMENTS.          -
C - - - - - - - - - - - - - - - - - - - - - - -
      DO 135 I=1,11
      DO 135 J=1,2
  135 FENCES(I,J) = 0.0
      DISPLAY "IF YOU WISH TO 'FENCE' A PE VALUE, ENTER ITS ROW "
      DISPLAY "NUMBER AND THE DOLLAR VALUE(IN THOUSANDS) SEPARATED"
      DISPLAY "BY A COMMA. WHEN NO FURTHER 'FENCING' IS DESIRED,"
      DISPLAY "ENTER 0,0"
  140 ACCEPT IROW,VALUE
      IF(IROW.EQ.0) GO TO 200
      FENCES(IROW,2) = VALUE/FACTOR
      FENCES(IROW,1) = IROW
      DISPLAY "ENTER NEXT 'FENCE' OR 0,0"
      GO TO 140
  200 DO 145 I = 1,11
      IF(FENCES(I,1).EQ.0.0) GO TO 145
      IF(I.LE.3) RHS(I+19) = FENCES(I,2)
      IF(I.EQ.4 .OR. I.EQ.5) RHS(23) = FENCES(4,2) + FENCES(5,2)
      IF(I.EQ.6 .OR. I.EQ.7) RHS(18+I) = FENCES(I,2)
      IF(I.EQ.8 .OR. I.EQ.11) RHS(26) = FENCES(8,2) + FENCES(11,2)
      IF(I.EQ.9 .OR. I.EQ.10) RHS(18+I) = FENCES(I,2)
  145 CONTINUE
C - - - - - - - - - - - - - - - - - - - - - - -
C  ADJUST TOTAL AVAILABLE BUDGET.           -
C - - - - - - - - - - - - - - - - - - - - - - -
      DIRECT = 0.0
      DISPLAY "ENTER THE TOTAL FUNDS AVAILABLE (IF THIS IS"
      DISPLAY "TO BE THE SAME AS THE TOTAL ABOVE, ENTER 0 )"
      ACCEPT DIRECT
      IF(DIRECT.EQ.0.0) GO TO 150
      RHS(1) = DIRECT/FACTOR
      GO TO 160
  150 RHS(1) = BUDGET/FACTOR
C - - - - - - - - - - - - - - - - - - - - - - -
C  RETAIN ORIGINAL RIGHT-HAND-SIDE          -
C  VALUES AS "RHS1".                        -
C - - - - - - - - - - - - - - - - - - - - - - -
  160 DO 170 I=1,NROWS
  170 RHS1(I) = RHS(I)
      DISPLAY "END OF PAGE 1"
      ACCEPT GARBAGE
C - - - - - - - - - - - - - - - - - - - - - - -
C  GOAL PROGRAMMING ITERATIONS.             -
C - - - - - - - - - - - - - - - - - - - - - - -
C  VARIABLES IN ASCENDING NUMERICAL         -
C  ORDER IN INITIAL TABLEAU.                -
C - - - - - - - - - - - - - - - - - - - - - - -
      DO 2 J=1,NVAR
2     X(J)=J
```

```
C - - - - - - - - - - - - - - - - - - - - -
C  ORIGINAL BASIS CONSISTS OF THE NROW    -
C  NEGATIVE DEVIATIONAL VARIABLES IN      -
C  FIRST NROW COLUMNS OF THE TABLEAU.     -
C - - - - - - - - - - - - - - - - - - - - -
      DO 3 I=1,NROWS
3     Y(I)=I
C - - - - - - - - - - - - - - - - - - - - -
C  INITIALIZE VALY(I,K) FOR ITERATION 1 -
C  VALY(I,K) -> (ROW,PRIORITY)            -
C  VALX(K,I) -> (PRIORITY,VARIABLE)       -
C - - - - - - - - - - - - - - - - - - - - -
      DO 4 K=1,NPRT
      DO 4 I=1,NROWS
      VALY(I,K)=VALX(K,I)
4     CONTINUE
      ITER=0
C - - - - - - - - - - - - - - - - - - - - -
C  CALCULATE ZJ-CJ FOR EACH VARIABLE AT -
C  EACH PRIORITY LEVEL -> RVLX(K,J)       -
C  NOTE: VALY HAS LOWEST PRIORITY IN      -
C           COLUMN 1, HIGHEST IN LAST COL. -
C           VALX HAS LOWEST PRIORITY IN   -
C           ROW 1, HIGHEST IN LAST ROW.   -
C           K3 USED TO "BACK THRU" ARRAYS. -
C - - - - - - - - - - - - - - - - - - - - -
      L1=0
5     K3=NPRT-L1
      IF (K3-1) 46,6,6
6     DO 8 K=1,K3
      DO 8 J=1,NVAR
      SUMP=0.
      DO 7 I=1,NROWS
      P=VALY(I,K)*C(I,J)
      SUMP=SUMP+P
7     CONTINUE
      IF(ABS(SUMP).LT.0.00001) SUMP = 0
      RVLX(K,J)=SUMP-VALX(K,J)
      IF(ABS(RVLX(K,J)).LT.0.00001) RVLX(K,J) = 0.0
8     CONTINUE
C - - - - - - - - - - - - - - - - - - - - -
C  DETERMINE ENTERING VARIABLE -> X(K2) -
C  FIND GREATEST ZJ-CJ  (RVLX)            -
C - - - - - - - - - - - - - - - - - - - - -
      ZMAX=0.
      DO 13 J=1,NVAR
C***SKIP HIGHER PRIORITY CHECK WHEN ON PRIORITY 1***
      IF (K3-NPRT) 9,11,11
C***CHECK ZJ-CJ FOR HIGHER PRIORITIES***
9     K4=K3+1
      DO 10 K=K4,NPRT
      IF (RVLX(K,J)) 13,10,10
10    CONTINUE
11    IF (RVLX(K3,J)-ZMAX) 13,13,12
12    ZMAX=RVLX(K3,J)
      K2=J
```

```
   13    CONTINUE
C - - - - - - - - - - - - - - - - - - - - - - -
C  OPTIMALITY CHECK:                           -
C       ZMAX GTE 0                             -
C       K3   GTE 1                             -
C       K3-1-ZMAX = 0 CAN OCCUR ONLY           -
C  WHEN:  K3 = 1                               -
C           ZMAX  = 0                          -
C  HENCE, OPTIMAL SOLUTION TO PROBLEM.         -
C - - - - - - - - - - - - - - - - - - - - - - -
         IF (K3-1+ZMAX) 14,46,14
C - - - - - - - - - - - - - - - - - - - - - - -
C  OPTIMALITY CHECK FOR PRIORITY LEVEL         -
C  L1+1 (ROW K3 OF RVALX).                     -
C  ZMAX GT 0 IS NOT OPTIMAL                    -
C - - - - - - - - - - - - - - - - - - - - - - -
   14    IF (ZMAX) 45,45,15
C - - - - - - - - - - - - - - - - - - - - - - -
C  DETERMINE VARIABLE TO LEAVE BASIS           -
C  USING MINIMUM RATIO RULE.  RATIO            -
C  (AMT(I)) IS CALCULATED FOR ALL ROWS         -
C  WITH A POSITIVE COEFFICIENT IN              -
C  COLUMN K2 AND THE MINIMUM IS CHOSEN         -
C  TO BE REMOVED (ROW K1).                     -
C - - - - - - - - - - - - - - - - - - - - - - -
   15    DO 20 I=1,NROWS
         IF (RHS(I)) 16,17,17
   16    WRITE (6,59)  RHS(I),I,ITER
         GO TO 55
   17    IF (C(I,K2)) 18,18,19
   18    AMT(I)=-1.
         GO TO 20
   19    AMT(I)= RHS(I)/C(I,K2)
   20    CONTINUE
         I=1
   21    IF (AMT(I)) 22,24,24
   22    I=I+1
         IF (I-NROWS) 21,21,23
   23    WRITE (6,60) ITER
         GO TO 55
   24    ZMIN=AMT(I)
         K1=I
   25    I=I+1
         IF (I-NROWS) 26,26,28
   26    IF (AMT(I)) 25,27,27
   27    IF (ZMIN-AMT(I)) 25,25,24
C - - - - - - - - - - - - - - - - - - - - - - -
C  REDESIGNATE BASIC VARIABLE AND CJ           -
C  COEFFICIENTS.                               -
C - - - - - - - - - - - - - - - - - - - - - - -
   28    Y(K1)=X(K2)
         DO 29 K=1,NPRT
         VALY(K1,K)=VALX(K,K2)
   29    CONTINUE
```

```
C - - - - - - - - - - - - - - - - - - - - - - - - -
C  CALCULATE NEW RIGHT-HAND-SIDE VALUES -
C - - - - - - - - - - - - - - - - - - - - - - - - -
      DO 30 I=1,NROWS
      RHS(I) = RHS(I)-ZMIN*C(I,K2)
30    CONTINUE
      RHS(K1)=ZMIN
C - - - - - - - - - - - - - - - - - - - - - - - - -
C  SUBROUTINE PIVOT CALCULATES THE NEW   -
C  COEFFICIENT MATRIX FOR NEXT           -
C  ITERATION.                            -
C - - - - - - - - - - - - - - - - - - - - - - - - -
      CALL PIVOT(NVAR,NROWS,K1,C,K2)
C - - - - - - - - - - - - - - - - - - - - - - - - -
C  INCREMENT COUNTERS AND ITERATE.       -
C - - - - - - - - - - - - - - - - - - - - - - - - -
      ITER=ITER+1
      GO TO 6
45    L1=L1+1
      GO TO 5
C - - - - - - - - - - - - - - - - - - - - - - - - -
C  SUBROUTINE FINAL PRINTS ALL OUTPUT.   -
C  THE USER MAY THEN CYCLE THROUGH THE   -
C  PROGRAM AGAIN OR TERMINATE.           -
C - - - - - - - - - - - - - - - - - - - - - - - - -
   46 CALL FINAL(NROWS,NVAR,RHS1,RHS,Y,COBE,SUM,COBPRE,NWLPI,FACTOR)
      GO = 0.0
      DISPLAY "END OF PAGE 3"
      DISPLAY " IF YOU WANT TO MAKE FURTHER CHANGES, ENTER A 1 "
      DISPLAY " ANY OTHER ENTRY WILL TERMINATE THE PROGRAM. "
      ACCEPT GO
      IF(GO.EQ.1) GO TO 9999
   55 STOP
59    FORMAT (//,10X,44H***ERROR***  RHS VALUE LESS THAN 0 ,VALUE = ,F9
     12,/25X,7H ROW # ,I3,13H ITERATION # ,I3)
60    FORMAT (//,10X,56HALL LIMITING AMOUNTS FOR RHS/A(I,J) VALUES LESS
     1THAN 0. ,/15X,32HINFEASIBLE SOLUTION AT ITERATION,I3)
      END
```

```
C**********************************************************************
C                                                                     *
C  SUBROUTINE START
C     SUBROUTINE START READS IN ALL THE INITIAL DATA FOR THE GOAL     *
C     PROGRAMMING MODEL.  THIS DATA IS STORED IN THE APPROPRIATE      *
C     ARRAYS AND SOME CHECKS ARE PERFORMED TO INSURE THE DATA IS IN   *
C     THE PROPER FORM.  ARTIFICIAL AND DEVIATIONAL VARIABLES ARE      *
C     ASSIGNED AND THE PRIORITY STRUCTURE IS ESTABLISHED.             *
C                                                                     *
C  VARIABLE DEFINITION IN SUBROUTINE START                            *
C     EQUALS(I)    SIGN VALUE (E,B,G OR L) FOR I TH CONSTRAINT        *
C     ICOUNT       TEMPORY COUNTER FOR NUMBER OF RECORDS READ         *
C     OSGN(I)      POS OR NEG -> TYPE VARIABLE FOR PRIORITY STRUCTURE*
C     OFUN(I,J)    (ROW,PRIORITY,WEIGHT) FOR OSGN(I)                  *
C     NPRI         NUMBER OF RECORDS READ FOR PRIORITY STRUCTURE      *
C     OMAX(I,J)    TECHNOLOGICAL COEFFICIENTS(ROW,COLUMN,VALUE)       *
C     NMAT         NUMBER OF RECORDS READ FOR TECHNOLOGICAL           *
C                  COEFFICIENTS                                       *
C     NART         NUMBER OF ARTIFICIAL VARIABLES ADDED               *
C     NFLDS        NUMBER OF POSITIVE DEVIATIONAL VARIABLES ADDED     *
C     NSIZE        TOTAL NUMBER OF COLUMNS IN C MATRIX                *
C     NUM          MAX (NPRT,NROWS) -> SIZE OF BASIS                  *
C     KEPT(I)      VARIABLE NUMBER OF POSITIVE DEVIATIONAL VARIABLE   *
C                  FOR ROW I                                          *
C     KPCK         COUNTER FOR PLACING POSITIVE DEVIATIONAL VARIABLES*
C                  IN APPROPRIATE COLUMN                              *
C     NVAR         SET EQUAL TO NSIZE, TOTAL NUMBER OF COLUMNS,       *
C                  BEFORE RETURN TO MAIN PROGRAM                      *
C                                                                     *
C**********************************************************************
      SUBROUTINE START(NROWS,NVAR,NPRT,C,VALX,VALY,RHS,RVLX)
      DIMENSION OSGN(104),OFUN(3,104),OMAX(3,150),BHS(41),EQUALS(41)
      DIMENSION C(41,102),RVLX(6,102),VALX(6,102),VALY(41,5),
     *KEPT(41),RHS(41)
      CHARACTER*4 PROB
      CHARACTER*1 B,E,G,L
      CHARACTER*4 POS,NEG,OBJ,OSGN
      CHARACTER*4 PO,NE
      CHARACTER*4 DATA,RGHT
      CHARACTER*1 EQUALS
      CHARACTER*4 ANAME,DISK
      CHARACTER*4 END
      DATA END/"END,"/
      DATA DISK/4HDISK/
      DATA POS,NEG,PO,NE/4HPOS ,4HNEG ,4HPOS,,4HNEG,/
      DATA DATA,OBJ,PROB/4HDATA,4HOBJ ,4HPROB/
      DATA B,E,G,L/1HB,1HE,1HG,1HL/
      DATA RGHT/4HRGHT/
```

```
C - - - - - - - - - - - - - - - - - - - - - - -
C  READ NUMBER OF ROWS,VARIABLES,            -
C  PRIORITY LEVELS AND SENSE OF GOALS.       -
C - - - - - - - - - - - - - - - - - - - - - - -
      READ(101,*) NROWS
      READ(102,*) NVAR
      READ(103,*) NPRT
      READ(104,*) (EQUALS(I),I=1,28)
      READ(105,*)(EQUALS(I),I=29,NROWS)
C - - - - - - - - - - - - - - - - - - - - - - -
C  READ IN PRIORITY STRUCTURE:               -
C      OSGN -> POS OR NEG DEVIATION          -
C      OFUN -> (ROW ,PRIORITY,WEIGHT)        -
C      NPRI -> NUMBER OF RECORDS READ        -
C - - - - - - - - - - - - - - - - - - - - - - -
      ICOUNT=0
  100 ICOUNT=ICOUNT+1
      II=ICOUNT+5
      READ(10II,*) OSGN(ICOUNT),(OFUN(J,ICOUNT),J=1,3)
      IF(OSGN(ICOUNT).EQ.PO) OSGN(ICOUNT)=POS
      IF(OSGN(ICOUNT).EQ.NE) OSGN(ICOUNT)=NEG
      IF(OSGN(ICOUNT).EQ.END) GO TO 110
      GO TO 100
  110 NPRI=ICOUNT
      ICOUNT=0
C - - - - - - - - - - - - - - - - - - - - - - -
C  READ IN TECHNOLOGICAL COEFFICIENTS:       -
C      OMAX -> (ROW,COLUMN,VALUE)            -
C      NMAT -> NUMBER OF RECORDS READ        -
C - - - - - - - - - - - - - - - - - - - - - - -
  120 ICOUNT=ICOUNT+1
      II=ICOUNT+5+NPRI
      READ(10II,*) (OMAX(J,ICOUNT),J=1,3)
      IF(OMAX(1,ICOUNT).LE.0) GO TO 130
      GO TO 120
  130 NMAT=ICOUNT
C - - - - - - - - - - - - - - - - - - - - - - -
C  READ IN RIGHT-HAND-SIDE VALUES            -
C - - - - - - - - - - - - - - - - - - - - - - -
      DO 140 JJ=1,NROWS
      II=JJ+NMAT+NPRI+5
      READ(10II,*) RHS(JJ)
  140 CONTINUE
      NART=0
      NFLOS=0
```

```
C - - - - - - - - - - - - - - - - - - - -
C  NFLDS => NUMBER OF POSITIVE           -
C           DEVIATIONAL VARIABLES ADDED -
C - - - - - - - - - - - - - - - - - - - -
      DO 1 I=1,NROWS
      IF (EQUALS(I).EQ.B) NFLDS=NFLDS+1
    1 IF (EQUALS(I).EQ.G) NFLDS=NFLDS+1
      NSIZE=NFLDS+NROWS+NVAR
      IF (NPRT.GT.NROWS) GO TO 2
      NUM=NROWS
      GO TO 3
    2 NUM=NPRT
C - - - - - - - - - - - - - - - - - - - -
C  LAST ROW OF VALX TO BE USED AS A     -
C  LOCATOR FOR ARTIFICIAL VARIABLES.    -
C - - - - - - - - - - - - - - - - - - - -
    3 KDUD=NPRT+1
      DO 4 KX=1,NSIZE
    4 VALX(KDUD,KX)=0.0
C - - - - - - - - - - - - - - - - - - - -
C  CLEAR RVLX,VALX AND C MATRICES.      -
C  FIRST NUM COLUMNS OF COEFFICIENT     -
C  MATRIX(C) SET UP AS IDENTITY MATRIX  -
C  CORRESPONDING TO THE INITIAL BASIS   -
C  (NEG DEVIATIONAL AND ARTIFICIAL      -
C  VARIABLES).                          -
C - - - - - - - - - - - - - - - - - - - -
      DO 6 J=1,NSIZE
      DO 6 I=1,NUM
      KEPT(I)=0
      IF (I.GT.KDUD) GO TO 5
      K=I
      RVLX(K,J)=0.0
      VALX(K,J)=0.0
    5 IF (I.EQ.J) C(I,J)=1.0
      VALY(I,K)=0.0
      IF (I.NE.J) C(I,J)=0.0
    6 CONTINUE
      KPCK=0
      K=KDUD
C - - - - - - - - - - - - - - - - - - - -
C  CHECK SENSE OF GOALS TO DETERMINE    -
C  LOCATION OF ARTIFICIAL AND POSITIVE  -
C  DEVIATIONAL VARIABLES. ARTIFICIALS   -
C  ARE INDICATED BY A 1 IN EXTRA ROW    -
C  OF VALX MATRIX.  POS DEVIATIONALS    -
C  APPEAR IN NEXT KPCK COLUMNS OF C     -
C  MATRIX AFTER INITIAL BASIS FORMED    -
C  EARLIER.                             -
C - - - - - - - - - - - - - - - - - - - -
      DO 10 I=1,NROWS
      IF (EQUALS(I).EQ.E) GO TO 7
      IF (EQUALS(I).EQ.G) GO TO 8
      IF (EQUALS(I).EQ.L) GO TO 10
      IF (EQUALS(I).EQ.B) GO TO 9
      GO TO 22
```

```
7       J=I
        VALX(K,J)=1.0
        NART=NART+1
        GO TO 10
8       KPCK=KPCK+1
        J=NROWS+KPCK
        C(I,J)=-1.0
        KEPT(I)=J
        J=I
        VALX(K,J)=1.
        NART=NART+1
        GO TO 10
9       KPCK=KPCK+1
        J=KPCK+NROWS
        C(I,J)=-1.0
        KEPT(I)=J
10      CONTINUE
C - - - - - - - - - - - - - - - - - - - - - - -
C  PLACE OBJECTIVE FUNCTION COEFFICIENTS-
C  IN POSITION IN VALX MATRIX.          -
C  NOTE: LOWEST PRIORITY IN FIRST ROW.  -
C - - - - - - - - - - - - - - - - - - - - - - -
        ANAME=OBJ
        ICOUNT=0
11       ICOUNT=ICOUNT+1
        IF(ICOUNT.GE.NPRI)GO TO 6999
        I=OFUN(1,ICOUNT)
        M=OFUN(2,ICOUNT)
        TEMP=OFUN(3,ICOUNT)
        ANAME=OSGN(ICOUNT)
7622    IF (ANAME.EQ.DATA) GO TO 6999
        IF (M.LE.0) GO TO 26
        K=NPRT+1-M
        IF (J.LE.0) GO TO 26
        IF (K.GT.NPRT) GO TO 29
        IF (ANAME.EQ.NEG) GO TO 12
        IF (ANAME.EQ.POS) GO TO 13
        GO TO 14
12      J=I
        IF (EQUALS(I).EQ.G.OR.EQUALS(I).EQ.E) GO TO 33
        VALX(K,J)=TEMP
        GO TO 11
13      J=KEPT(I)
        IF (KEPT(I).EQ.0) GO TO 28
        VALX(K,J)=TEMP
        GO TO 11
14      IF (TEMP) 31,11,31
```

```
C - - - - - - - - - - - - - - - - - - - - - - -
C  FILL REMAINDER OF C MATRIX WITH            -
C  TECHNOLOGICAL COEFFICIENTS.                -
C - - - - - - - - - - - - - - - - - - - - - - -
6999  ICOUNT=0
15    ICOUNT=ICOUNT+1
      IF(ICOUNT.GE.NMAT)GO TO 16
      I=OMAX(1,ICOUNT)
      J=OMAX(2,ICOUNT)
      TEMP=OMAX(3,ICOUNT)
19078  IF(I.LE.0)GO TO 23
      IF (J.EQ.0) GO TO 23
      J=KPCK+NROWS+J
      C(I,J)=TEMP
      GO TO 15
   16 NVAR=NSIZE
      IF (NART.GT.0) NPRT=NPRT+1
      RETURN
C - - - - - - - - - - - - - - - - - - - - - - -
C       ERROR MESSAGES                        -
C - - - - - - - - - - - - - - - - - - - - - - -
22    WRITE (6,50)
      GO TO 34
23    WRITE (6,51) ANAME,I,J,TEMP
      GO TO 34
26    WRITE (6,54)
      GO TO 34
28    WRITE (6,56) EQUALS(I),ANAME,I,M,TEMP
      GO TO 34
29    WRITE (6,57)
      GO TO 34
31    WRITE (6,59)
      GO TO 34
33    WRITE (6,61) EQUALS(I),ANAME,I,M,TEMP
34     STOP
50     FORMAT(" PROGRAM CONTAINS AN ERROR EITHER IN THE NUMBER OF ROWS",
      1" PUNCHED"/" OR IN THE SIGN CARD. THE VALUE IS SOMETHING OTHER",
      1" THAN E G OR L")
51     FORMAT (//,10X,59H***ERROR*** A COLUMN OR ROW IS DEFINED WITH A V
      1LUE OF ZERO,/30X,17HCARD APPEARS AS :,A4,2I5,F16.0)
54     FORMAT (70H  COLUMN VALUE OR PRIORITY VALUE IS EQUAL TO OR LESS T
      1AN ZERO         )
56     FORMAT (62H  ATTEMPT IS MADE TO MINIMIZE NON EXISTANT POSITIVE  D
      1VIATION,/,13H THE SIGN IS ,A1,/,36H THE OBJECTIVE FUNCTION DATA C
      2RD IS,/,1X,A4,2I5,F20.6)
57     FORMAT (65H  OBJECTIVE FUNCTION PRIORITY EXCEEDS STATED NUMBER OF
      1PRIORITIES)
59     FORMAT(" A CARD IN THE OBJECTIVE SECTION DEFINED SOME VALUE",/,
      1" FOR THE OBJECTIVE FUNCTION BUT FAILED TO DEFINE WHETHER THIS",/
      1" WAS TO APPLY TO THE POSITIVE OR NEGATIVE DEVIATION")
61     FORMAT (62H ATTEMPT IS MADE TO MINIMIZE A NON EXISTANT NEGATIVE D
      1VIATION,/,14H THE SIGN IS  ,A1,/,36H THE OBJECTIVE FUNCTION DATA
      2ARD IS,/,1X,A4,2I5,F16.5)
       END
```

```
C*********************************************************************
C                                                                    *
C  SUBROUTINE FINAL                                                  *
C     SUBROUTINE FINAL IDENTIFIES THE DEVIATIONAL AND DECISION       *
C     VARIABLES IN THE SOLUTION TO THE GOAL PROGRAMMING PROBLEM      *
C     SOLVED IN THE MAIN PROGRAM.  OUTPUT PREDICTIONS FOR THE        *
C     EXISTING BUDGET ALLOCATION(FILE=2) AND THE GOAL PROGRAMMING    *
C     SOLUTION ARE MADE.  THE PREDICTION FOR THE EXISTING            *
C     ALLOCATION IS MADE BY ADJUSTING THE VARIABLE COBPRE,           *
C     CALCULATED IN THE MAIN PROGRAM, BY THE REGRESSION CONSTANT.    *
C     THE PREDICTION FOR THE GOAL PROGAMMING SOLUTION IS MADE BY     *
C     ADDING OR SUBTRACTING THE APPROPRIATE DEVIATIONAL VARIABLE     *
C     FROM THE CORRESPONDING GOAL.  ALL RESULTS ARE THEN PRINTED     *
C     AS THE FINAL PAGE OF OUTPUT.                                   *
C                                                                    *
C  VARIABLE DEFINITIONS IN SUBROUTINE FINAL                          *
C     BUDG(I)       "OPTIMAL" ALLOCATION OF THE BUDGET COMPUTED BY   *
C                   THE GOAL PROGRAMMING ALGORITHM                   *
C     A,B,C,D       TEMPORY VARIABLES FOR STORING COLUMN SUMS OF     *
C                   BUDGET ALLOCATIONS                               *
C     PE(I)         NUMERIC DESIGNATION OF PROGRAM ELEMENTS          *
C     DEV(I,J)      VALUE OF DEVIATIONAL VARIABLES FOR THE WORKLOAD/ *
C                   PERFORMANCE EQUATIONS                            *
C     GOAL1(I)      COBE GOALS FOR WORKLOAD/PERFORMANCE EQUATIONS    *
C     GOAL(I)       PREDICTED WORKLOAD/PERFORMANCE OUTPUT FOR THE    *
C                   COMPUTED SOLUTION -> BUDG(I)                     *
C                                                                    *
C*********************************************************************
      SUBROUTINE FINAL(NROWS,NVAR,RHS1,RHS,Y,COBE,SUM,COBPRE,NALPI,
     *                 FACTOR)
      DIMENSION RHS1(41),RHS(41),Y(41),BUDG(9),DEV(13,2),GOAL(13)
      DIMENSION GOAL1(13),COBE(11,3),DIFF(13),PE(9),SUM(11),COBPRE(13)
      DIMENSION DIFFC(13)
      CHARACTER*9 PE
      DATA PE(1),PE(2),PE(3)/9H721111   ,9H721112   ,9H721113   /
      DATA PE(4),PE(5),PE(6)/9H722829/98,9H722896.Z ,9H728009   /
      DATA PE(7),PE(8),PE(9)/9H728010/13,9H728011   ,9H728012   /
      DO 100 I=1,3
C - - - - - - - - - - - - - - - - - -
C  ALL THREE PORTIONS OF THE EXISTING   -
C  COBE(FILE=2) ARE CONDENSED FROM THE  -
C  11 PROGRAM ELEMENTS READ IN TO THE   -
C  9 USED IN THE PROGRAM.               -
C - - - - - - - - - - - - - - - - - -
  100 COBE(4,I) = COBE(4,I) + COBE(5,I)
      DO 110 I=6,7
      DO 110 J=1,3
  110 COBE(I-1,J) = COBE(I,J)
      DO 120 I=1,3
  120 COBE(7,I) = COBE(8,I) + COBE(11,I)
      DO 130 I=9,10
      DO 130 J=1,3
  130 COBE(I-1,J) = COBE(I,J)
   50 J=NROWS*2 + 1
      WRITE (6,71)
```

```
   71 FORMAT(1H1,25X,6HDIRECT,27X,5HTOTAL,//,1H ,9HPROG ELEM,10X,4HCOBE,
     *        11X,5HMODEL,13X,4HCOBE,10X,5HMODEL,//)
C - - - - - - - - - - - - - - - - - - - -
C  INITIALIZE BUDG TO 0.                   -
C - - - - - - - - - - - - - - - - - - - -
      DO 52 I = 1,9
   52 BUDG(I) = 0.0
C - - - - - - - - - - - - - - - - - - - -
C  IDENTIFY THE DECISION VARIABLES IN      -
C  THE GOAL PROGRAMMING SOLUTION AND       -
C  STORE AS BUDG(I).                       -
C - - - - - - - - - - - - - - - - - - - -
      KK = J-1
      DO 54 I = 1,NROWS
      DO 54 K = J,NVAR
      IF (Y(I) - K) 54,53,54
   53 BUDG(K - KK) = RHS(I)*FACTOR
   54 CONTINUE
C - - - - - - - - - - - - - - - - - - - -
C  COMPUTE TOTAL AND DIRECT COLUMN SUMS -
C  FOR THE SOLUTION AND EXISTING BUDGET -
C  AND PRINT RESULTS, INCLUDING THE        -
C  AMOUNT ALLOCATED TO EACH PROGRAM        -
C  ELEMENT.                                -
C - - - - - - - - - - - - - - - - - - - -
      A = 0.0
      B = 0.0
      C = 0.0
      D = 0.0
      DO 80 I=1,9
      A = A+COBE(I,1)
      TEMP = BUDG(I)-COBE(I,2)-COBE(I,3)
      B = B+TEMP
      C = C+SUM(I)
      D = D+BUDG(I)
   80 WRITE(6,72) PE(I),COBE(I,1),TEMP,SUM(I),BUDG(I)
   72 FORMAT(1H ,A9,8X,F8.1,7X,F8.1,9X,F8.1,5X,F9.1)
      WRITE(6,76)
   76 FORMAT(1H ,17X,8H________,7X,8H________,9X,
     *        8H________,6X,9H_________)
      WRITE(6,77) A,B,C,D
   77 FORMAT(1H ,16X,F9.1,6X,F9.1,8X,F9.1,6X,F9.1,///)
      DISPLAY "END OF PAGE 2"
      ACCEPT GARBAGE
C - - - - - - - - - - - - - - - - - - - -
C  INITIALIZE DEV TO 0.                    -
C - - - - - - - - - - - - - - - - - - - -
      DO 55 I = 1,35
      DO 55 J=1,2
      DEV(I,J) = 0.0
   55 CONTINUE
```

```
C - - - - - - - - - - - - - - - - - - - - - - - -
C  IDENTIFY THE DEVIATIONAL VARIABLES          -
C  IN THE GOAL PROGRAMMING SOLUTION            -
C  WHICH CORRESPOND TO THE WORK-LOAD/          -
C  PERFORMANCE-INDICATOR EQUATIONS.            -
C - - - - - - - - - - - - - - - - - - - - - - - -
      DO 61 I=1,NROWS
      DO 60 K=29,NROWS
      IF(Y(I) - K) 58,57,58
   57 DEV(K-28,1) = RHS(I)
      GO TO 61
   58 IF(Y(I)-NROWS-K) 60,59,60
   59 DEV(K-28,2) = RHS(I)
      GO TO 61
   60 CONTINUE
   61 CONTINUE
      WRITE(6,73)
   73 FORMAT(1H1,45X,4HCOBE,14X,5HMODEL,/,1H ,8X,9HPARAMETER,
    *        11X,6H GOAL ,4X,6H PRED ,3X,6H DIFF ,4X,6H PRED ,
    *        3X,6H DIFF )
C - - - - - - - - - - - - - - - - - - - - - - - -
C  READ THE EXISTING COBE GOALS(FILE=2).-
C - - - - - - - - - - - - - - - - - - - - - - - -
      DO 200 I=1,NWLPI
  200 READ(2@I+12,*) GOAL1(I)
      REWIND 2
C - - - - - - - - - - - - - - - - - - - - - - - -
C  COMPUTE THE PREDICTIONS FOR THE             -
C  EXISTING BUDGET ALLOCATION(FILE=2)          -
C  AND THE GOAL PROGRAMMING SOLUTION.          -
C  PERFORMANCE INDICATOR PREDICTIONS           -
C  WHICH EXCEED 100% ARE LISTED AS 100%        -
C - - - - - - - - - - - - - - - - - - - - - - - -
      DO 96 I=1,7
      GOAL(I)=GOAL1(I)-DEV(I,1)+DEV(I,2)
   96 COBPRE(I)=COBPRE(I)+GOAL1(I)-RHS1(28+I)
      DO 97 I=8,12
      IF(I.EQ.11) GO TO 250
      COBPRE(I)=RHS1(28+I)+GOAL1(I)-COBPRE(I)
      GOAL(I)=GOAL1(I)+DEV(I,1)-DEV(I,2)
      GO TO 97
  250 COBPRE(11)=COBPRE(11)+GOAL1(11)-RHS1(39)
      GOAL(11)=GOAL1(11)-DEV(11,1)+DEV(11,2)
   97 CONTINUE
      COBPRE(13)=COBPRE(13)+GOAL1(13)-RHS1(41)
      GOAL(13)=GOAL1(13)-DEV(13,1)+DEV(13,2)
      DO 98 I=1,NWLPI
      DIFF(I)=GOAL(I)-GOAL1(I)
   98 DIFFC(I)=COBPRE(I)-GOAL1(I)
      DO 63 I = 7,NWLPI
      IF(GOAL(I).LE.100.0) GO TO 63
      GOAL(I) = 100.0
      DIFF(I) = 100.0 - GOAL1(I)
   63 CONTINUE
```

```
      DO 64 I = 7,NWLPI
      IF(COBPRE(I).LE.100.0) GO TO 64
      COBPRE(I) = 100.0
      DIFFC(I) = 100.0 - GOAL1(I)
   64 CONTINUE
C - - - - - - - - - - - - - - - - - - - - - -
C  WRITE ALL RESULTS.                        -
C - - - - - - - - - - - - - - - - - - - - - -
      WRITE(6,74)(GOAL1(I),COBPRE(I),DIFFC(I),GOAL(I),DIFF(I),I=1,6)
      WRITE(6,75)(GOAL1(I),COBPRE(I),DIFFC(I),GOAL(I),DIFF(I),I=7,NWLPI
   74 FORMAT(1H0,25HNO. ACTIONS INITIATED (K),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HREQN. PROCESSED TOTAL (K),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HTONS RECEIVED & SHPD  (K),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,2X,F7.1,/,
     *        1H0,25HLINE ITEMS SHIPPED    (K),3X,F6.1,4X,F6.1,2X,
     *        F7.1,4X,F6.1,2X,F7.1,/,
     *        1H0,25HPROCUREMENT ACTIONS   (K),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HTOTAL PROC(PA+BACKLOG)(K),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1)
   75 FORMAT(1H0,25HNICP OT REQN. PROC.   (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HDEPOT OT REQN. PROC.  (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HDARCOM REC. RATE-REPT.(%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HDARCOM OT REC.-STOW.  (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HDARCOM OT TRANS. RATE (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HLOCATION SURVEY ACC.  (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,/,
     *        1H0,25HSTOCK AVAIL. RATE     (%),3X,F6.1,4X,F6.1,3X,
     *        F6.1,4X,F6.1,3X,F6.1,//)
      RETURN
      END
```

```
C**********************************************************************
C                                                                     *
C   SUBROUTINE PIVOT                                                  *
C      SUBROUTINE PIVOT PERFORMS THE TRANSFORMATION OF THE            *
C      COEFFICIENT MATRIX FOR EACH ITERATION OF THE GOAL PROGRAMMING  *
C      ALGORITHM OF THE MAIN PROGRAM.  AS THE C MATRIX IS             *
C      TRANSFORMED,  THE NEW VALUES ARE TEMPORARILY STORED IN THE D   *
C      MATRIX.  WHEN TRANSFORMATION IS COMPLETE, THE D MATRIX IS      *
C      COPIED BACK INTO THE C MATRIX BEFORE RETURN TO THE MAIN        *
C      PROGRAM.  THUS ONLY ONE OF THESE LARGE MATRICES NEED BE        *
C      ACTIVE IN THE MAIN PROGRAM AT ANY TIME.  DEFINITION OF         *
C      VARIABLES IS THE SAME AS IN THE MAIN PROGRAM.                  *
C                                                                     *
C**********************************************************************
      SUBROUTINE PIVOT(NVAR,NROWS,K1,C,K2)
      DIMENSION C(41,102),D(41,102)
      DO 31 J=1,NVAR
      DO 31 I=1,NROWS
      IF (I.EQ.K1) GO TO 31
      D(I,J)=C(I,J)-C(K1,J)/C(K1,K2)*C(I,K2)
31    CONTINUE
      DO 32 J=1,NVAR
      D(K1,J)=C(K1,J)/C(K1,K2)
32    CONTINUE
      DO 33 I=1,NROWS
33    D(I,K2)=0.0
      D(K1,K2)=1.0
      DO 34 J=1,NVAR
      DO 34 I=1,NROWS
      C(I,J)=D(I,J)
      IF(ABS(C(I,J)).LT.0.00001) C(I,J) =0.0
34    CONTINUE
      RETURN
      END
```

ANNEX J

DISTRIBUTION LIST

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